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SCIENCE FICTION AND FACT

NOVEMBER 1992

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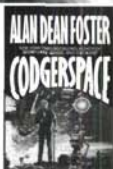
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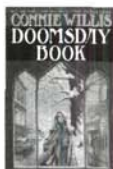
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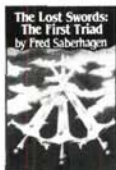
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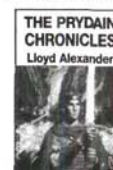
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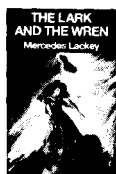
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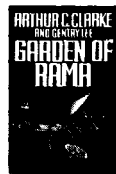
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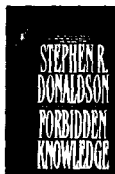
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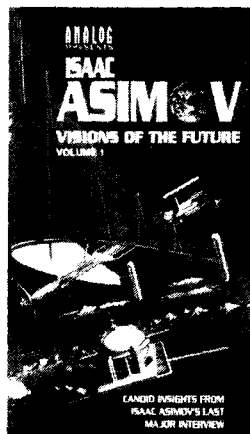
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Editorial

HOME RULE

Stanley Schmidt

It is appropriate at this time of year for conscientious American citizens to do their part, not only by voting, but by offering any suggestions they might have for the improvement of their government's operation. As luck would have it, I just happen to have such a suggestion.

I must preface my little offering with a grateful acknowledgment to Garrison Keillor, for the idea occurred to me while listening to a comedy sketch on his radio program, first aired in June 1991 from Wolf Trap Park, near Washington, DC. Appropriately, the hero of this "Lonesome Radio Theater" was a boy whose father was a US congressman—from Iowa, Kansas, or some similarly vague place in the Midwest. Nobody in the family seemed quite able to remember exactly where it was they were from, but our hero's mother occasionally warned him that someday

Daddy might lose an election and they'd have to go back there.

At this point one of those little comic-strip lights clicked on in my head. It occurred to me that while Keillor was joking, there was (as with all good satire) a sizable chunk of truth behind the jest. These days it's commonplace for congressmen and senators to stay in office for many consecutive terms. When that happens, they wind up spending most of their time for years or even decades living in Washington, with only occasional and relatively brief interludes in the districts they ostensibly represent. They become, in other words, Washingtonians.

Can a Washingtonian truly represent a state hundreds or thousands of miles away, even if he or she once lived there? Local concerns, after all, change with time. It seems painfully self-evident that somebody who moves off to Washington and lives primarily there must

in close touch with, and even with a vested interest in, conditions "back home." Ideally, we need a way to keep them in close full-time contact *both* with their constituents and with other legislators.

Yes, I know they visit, send questionnaires to their constituents, and otherwise try to gather pertinent information about life "back home." But wouldn't they be better representatives if it really *were* their home — if they still actually lived there?

And suddenly I saw how it could be done.

So I began considering whether there might be a way to arrange that, or at least approximate it more closely than the present system can.

With modern technology, it's really no great problem. It used to be necessary for lawmakers to physically meet in Washington; that's a large part of the reason the government is set up the way it is. Until relatively recently, communication between distant points was so slow that legislators *had* to gather under one roof, or nothing would ever get done.

My first thought was that consecutive terms should be prohibited. That way, in between relatively short periods of living in Washington, elected representatives would have comparable periods of being reimmersed in the life of their constituents. But that isn't really satisfactory. It involves a lot of moving back and forth, a real hardship on several levels, which I would not willingly inflict on even the least satisfactory congressperson. It also sacrifices the advantages of experience and familiarity with the government scene that a really good incumbent congressman or senator might have.

That simply isn't true any more. Rapidly growing numbers of employers and employees in many other professions are discovering that telecommuting can be at least as effective as spending time and money to bring employees to a central place in the morning and send them back at night. Some jobs can actually be done *better* by employees who spend much of their time at home, away from distractions like water coolers and congenial colleagues, provided they have some combination of telephones, computers, modems, and fax machines to

What we really need is a way to allow good legislators to keep those advantages—and at the same time keep them

[illegible]

communicate with the office when necessary.

How well it works depends, of course, on both the nature of the worker and the nature of the work. Some individuals *need* frequent social contact; others thrive on solitude. Some jobs, like writing, can be done virtually anywhere (I once wrote part of a published story while babysitting a two-year-old nephew in a beauty parlor), but work best with minimal distractions. Others are quite the opposite. The work of a hospital emergency room, for example, *has* to be done where the equipment is, and there has to be somebody there to do it every minute of every day.

Now think about what a congressman or senator is hired to do. Not a description of his actual day-by-day activities

under the present system, but the *purpose* he is elected and sworn to carry out.

An elected legislator's job is to represent the interests of his constituents—the residents of a particular region—in making laws that will serve well both them and the country as a whole. For the “country as a whole” part, he needs to be in touch with his colleagues who similarly represent other regions. The present system takes care of that very well—perhaps too well. The problem is the “representing his constituents” part, which the present system makes very difficult. The first thing we do after electing a representative is to send him far away from the people he's supposed to represent. Then we leave him there so long that he

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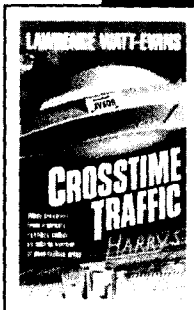
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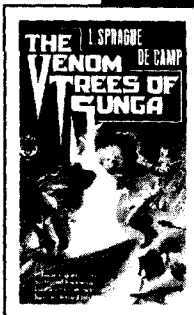
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AN ADVENTUROUS
ANTHROPOLOGIST—
FROM THE
FIRST NAME
IN
IMAGINATION...

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can easily forget what it feels like to be one of them.

My proposed solution is simple: *let's shut down the hallowed halls of Congress and let our representatives and senators stay home and telecommute.*

It's an option that simply didn't exist when the Constitution was drafted. Probably few people living then could even imagine it. But times have changed dramatically. A very large part of what legislators now do face to face could be done at least equally well electronically. Meanwhile, living their daily lives at home among the people they represent, paying the same kind of taxes, dealing with local businesses, experiencing firsthand whatever problems the local schools and sewage systems have—they *can't* forget what it's like. And chances are they'll have a much more acute interest in getting local problems *solved* than if they knew about them only by statistical summaries on a desk in Washington.

When I look at it that way, I find it hard to imagine a career better suited to telecommuting. Lots of jobs *can* be done that way, but for this one it has a unique, and large, advantage. For the first time in history, it would allow elected representatives to truly *be* representatives, closely and personally in

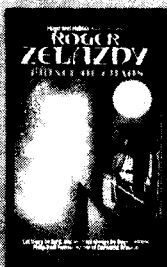
touch with their constituencies, instead of just "somebody who used to live here."

And if that's not enough to convince you, consider this incidental benefit (which may not be so incidental in a time when practically everyone is looking for ways to cut expenses and eliminate deficits.) We're often told that the exorbitant salaries paid Congress are necessary because its members must maintain two homes: one in Washington (where they really live) and one at "home" (so they'll have a place to go in case they get voted out someday). My modest proposal would have the desirable side effect of making that unnecessary. For the few times when they *need* to meet somebody face to face, a plane ticket and a hotel will do. In the long run, that should cost the taxpayers less than paying for all those second homes.

So . . . we use modern communications technologies to solve a problem that the Founding Fathers *couldn't* solve, and we get better representation (and therefore better government) at reduced cost. And members of Congress themselves should find all this a welcome change because it would make their lives ever so much simpler. Moving is, after all, quite a hassle. . . .

Worth a try? ■

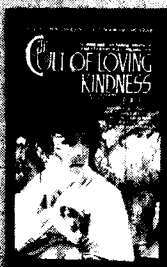
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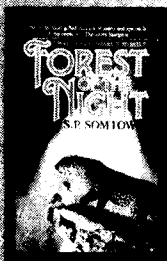
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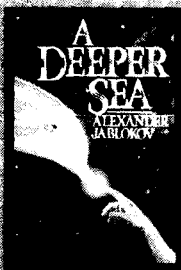
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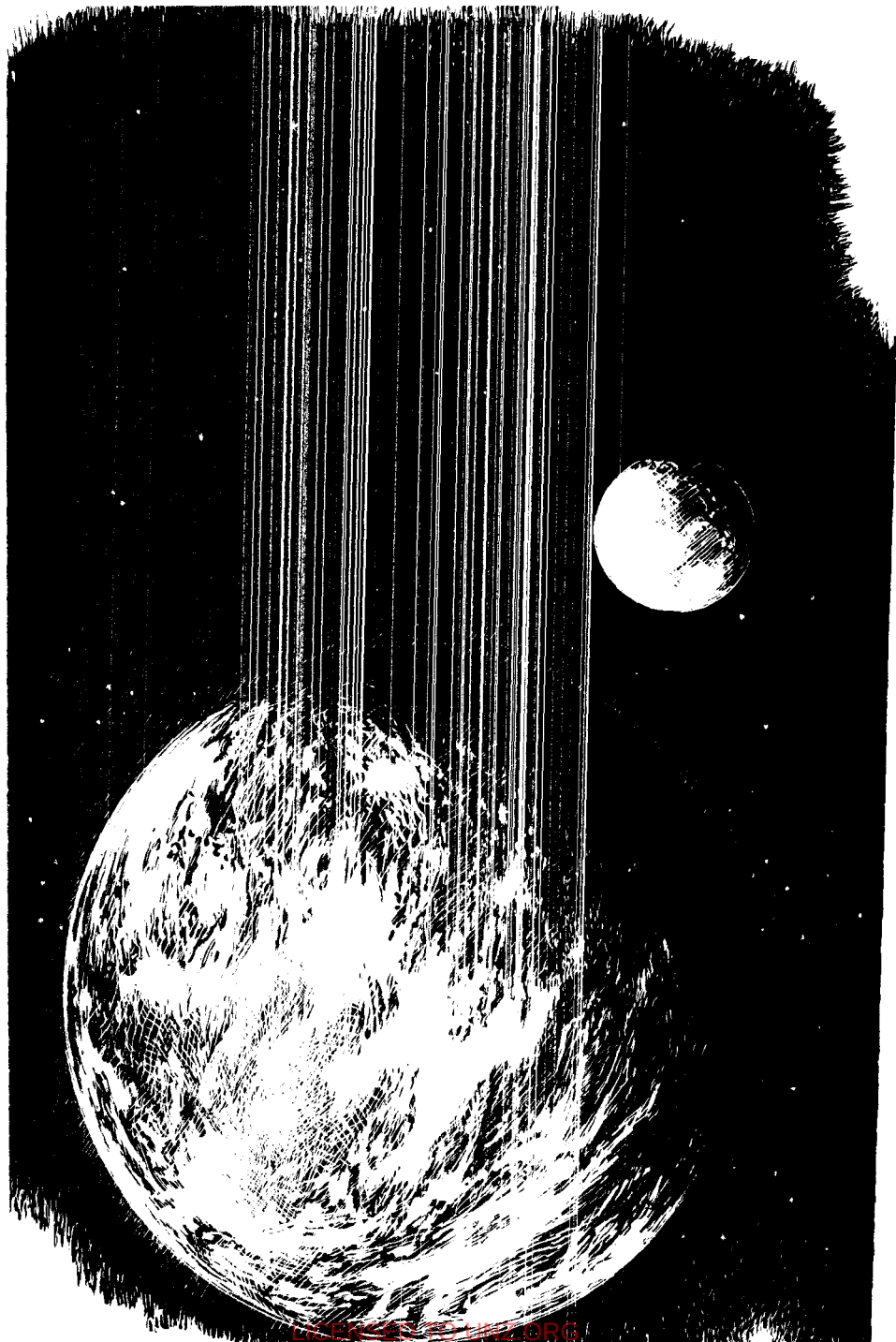
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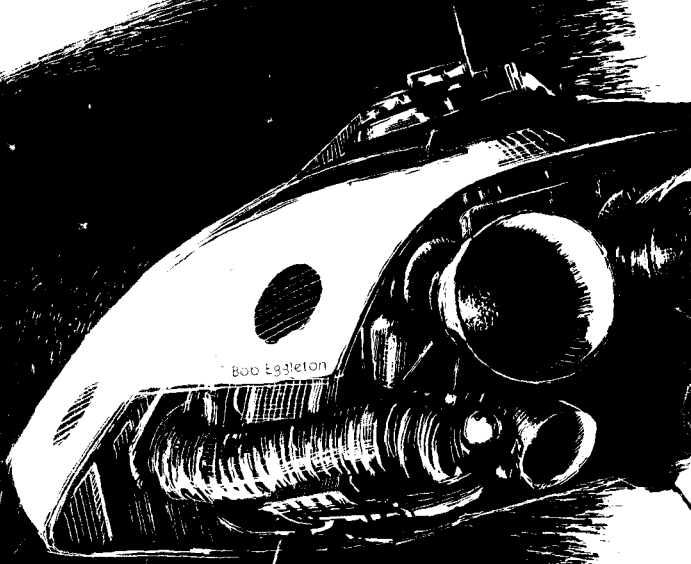
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EMBRACING THE ALIEN

Geoffrey A. Landis

Choices are often
difficult—but none
more so than this.



I write this in the human language, English. The very fact that I write in their language tells how much I have fallen.

To write down the deeds of others, black laser-carved hieroglyphs on thin white rectangles, what *timra* is there in this? This is not our way. The way of the true people is to share directly, breathe in our pod-mate's air, share each other's soil, and let our experiences merge, without interpretation, without words.

But the great pod-fathers have instructed us to embrace difference, to root with strangers and let our seed grow rich. The universe is great and we are small; if we fear change we will be destroyed, the pod-fathers tell us; and so I have been sent out to cross the universe in the company of strange-smelling, strangely shaped predators. I have come to adopt their ways, to think their thoughts and act their actions.

But understand them, I do not.

The ship of the humans travels at unimaginable speeds. Their curiosity is flickering, intense but transitory; they dart from place to place like pollinating insects, always pausing but never stopping to know any one place in fullness. I have seen marvels without end, some menacing, some harmless. They have no sense of pod, no sense of species-preservation beyond their selves. One day, I fear, they will in innocence awaken something greater than themselves that will destroy them without their ever knowing the danger. Before, I would have said that they could not conceive of such a threat. But I have seen it, have seen that they comprehend the threat, even embraced it. In truth,

they seem to accept species destruction. They embrace the alien.

I thought I understood them. Now I fear I cannot.

Torri is the name I have taken among the humans. The syllables are easy for them to pronounce, with no meaning in their language. In the true speech it is close in pronunciation to the word that means "alone."

The *City of Anchorage* is a ship of the humans' curiosity, and my duty station is to be aboard observing them. *City of Anchorage* was at once both a large ship and many small ones. The powered core ferried with it the scientific stations, each one itself a small ship. It would drop these stations to gather their data at sites of interest on planetary surfaces or in orbit near astrophysical sites, then vanish back into the invisible topology of FTL space.

Six of the stations had been dropped. The station with which I was observer was next. It had the name *Anchorage Station Seven*, but the humans referred to it only as the *Igloo*. Our drop was to be an unusual area of space given their designation "Praesepe cluster." The humans' gravity telescopes had shown mass there, but their optical telescopes showed nothing. They calculated that the cluster primary was a highly dense object, possibly a black hole. The humans, as always briefly curious about anything they thought unusual, wanted to drop our scientific station into the system to investigate further.

Through the large portal I saw only the emptiness of space, speckled by distant stars. The captain of the ship, Ringelman, was with the technician

light from our station.

Varju was a member of a species that didn't harm one themselves until the human named them the stripeyst; the color vents, a violet-grey surface color, were outside my range of vision. It was the only other non-human on the ship, and he always looked much like a member of the two-legs, slightly longer than the humans, two arms, and an oval head reaching out about 300 Kelvins. I saw him in a pool with the synchrotron, and in the triple-chambered reactor. He had been shot by a human about two centuries before the humans came, and they had assimilated him very quickly, and then he had been forgotten. I thought of him as a pet, and he only slightly disappointed me when I chose to be the pilot. He was very intelligent, he could read the mind of their star, and he could read from a star ever before the humans, that the humans were not a monopoly and our technology was not the humans' alone. He was a predator, not a prey, and he was maintained in a state of one-on-one relationship with me. The ship's system is indeed a predator, and I like the human's direct knowledge of the ship's knowledge, using the ship's knowledge. They call science, and they are trying to do what they can. The ship's accretion disk is a black hole, and the horizon is a black hole. The ship is of great age.

"What are we seeing?" said the pilot. "We are seeing a human."

"What are we seeing?" said the pilot. "We are seeing a human."

to the ship core she had no primary duties, and she was as likely to be up on the science level as in her piloting egg. "These things have a bad rep for swallowing ships."

"Black holes are quite fascinating astrophysical objects," said Varju. The tendrils behind his neck curled and uncurled slowly as he talked. "If one could approach the event horizon of a black hole, time would slow down. Inside the event horizon, according to theory, time and space reverse roles."

All I know is," said the pilot, "I don't want to be the one to try it."

"Can you get a telescope on it?" Captain Ringelman asked.

I could see it clearly, and was momentarily surprised that the humans couldn't. "It's right there," I said.

"I don't see anything," she said.

"It won't be more visible if you could see it in the infrared spectrum," I said, slightly apologetically, for the humans do not see very well beyond a very narrow spectrum, and dislike being reminded of it.

Varju turned to the view screen behind him and spoke to the computer. "Spectrum infrared center five microns compression three—" a faint blur became visible in the center of the computer screen as Varju continued without pausing—"magnification ten, contrast plus ten." The faint blur enlarged to fill most of the screen, showing a black disk with a dark red corona around it, similar to the human's Sun blocked by their large Moon.

"What are we seeing?" the pilot asked.

Varju answered with a distant, distracted air. "You're looking at the heat-

ing of interstellar gas as it falls into the black hole."

A wavering, reddish-blue shape started to glow at the edge of the disk. Varju frowned, a facial movement that he had apparently learned from the humans, although without flexible skin over his face the gesture appeared like a war-sign to me. "Something is happening on the event horizon."

"What is it?" asked the captain.

Varju seemed puzzled and slightly awed. His neck tendrils stood out straight. "I don't know."

I looked out the porthole and saw . . . something. I shut my infra-eyes, then my chromatic eyes, but could not decipher what I saw. I could feel it, too, like a slowly-changing electrostatic field. "My sense organs are picking something up. An energy of some kind."

"Good," said the captain. She smiled. "You'll have *something* to investigate. Prepare to drop the station."

The captain sent me down to find Jared Brown, her first mate (though as far as I could see he was not mated to the captain) and the commander of our station. His name was once mentioned as having an amusing overtone, since the name was opposite to the coloration of his skin. This is a human subtlety almost invisible against the infrared glow of their body temperature, but it was explained that a lightness of skin pigment was quite unusual.

He was off-shift, but it was not yet his sleep schedule.

The core of the human ship is larger than it has need to be, with whole rooms devoted to specialized socializing activ-

ities. I found him in the commons room sipping at a mixture of ethanol and water. This is a chemical combination poisonous for us, but necessary for metabolic function in some (but not all) humans. He sat at a table with a personal viewer, musing over some sort of two-dimensional images. Another, a woman, had entered just before me. I knew her; she and Brown had been doing a courtship dance for several days. The captain had not specified urgency, so I took this as an opportunity to observe humans, my primary mission.

She rested her head on her hands and looked silently across at him. After a moment he looked up at her. I couldn't interpret his expression.

Apparently she could. "You look . . . sad?" she said "Wistful?"

"Just a bit nostalgic, I guess." He sighed.

"You want to talk?"

Brown silently slid the viewer around so she could see the photographs. "Memories from college."

"A friend?"

"Someone I knew."

"Ah." Her tone was carefully neutral. "Why are you thinking about her now?"

"Black hole," he said "Being so close to one now brought her to mind. She was on the *Beagle* when it entered the Cygnus X-1 system."

"Ah," she said. The Cygnus X-1 disaster was well known by space-farers; even I knew of it. She didn't have to say anything more.

"She died as she wanted to live, doing the work she loved," he said. He shook his head and smiled. "Pretty lucky, eh? How many of us get a chance

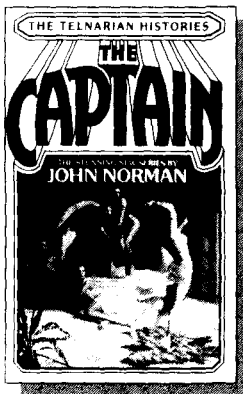
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like that? I'm told that her preliminary report on Cygnus X-1 is still a classic in the field." He paused. "She had a real talent for physics. She could have. . . ." Brown paused again, searching for words. "I don't know. She had such talent, such great potential. But never got a real chance to see where it would lead."

He shook his head and picked up his drink. "Maybe that's good. Maybe it's better to die young, never be disappointed. I was offered a slot on the *Beagle*. If things had been otherwise, I might have been there too."

"Do you think you could have made a difference?"

"Saved the expedition? Of course not. I could have died with her."

They were both silent for a moment, and I considered that an appropriate time to announce my presence.

Brown looked up. "I'm sorry. Were you looking for me?"

"We're ready to drop as soon as you are. The captain wants you up-deck."

He stood up. "Hell. OK. OK. Tell her I'm on my way."

There were just the four of us in the station as we prepared for the drop: Brown, now commander of the station, Varju and I, and Stakowski in her piloting egg. Our weight fell away as the *City of Anchorage* slowed rotation, and then suddenly the all-pervasive low note of the station changed timbre. We had separated from the ship-core. Our pilot steadied the station, and in the view-screen we watched the ship-core spin-up. Brown checked the function, Varju and I checked Brown, and Stakowski, presumably, ran her own checks. We

were in orbit, and functioning perfectly. Brown took the radio. "Looking good here, guys. See you in two weeks. Don't be late. OK?"

"We'll be there," came the reply. "Have a good session."

And suddenly the *City of Anchorage* sparkled and vanished. We were alone.

I watched the black hole in the viewport. I had no duties requiring immediate action, and I watched it, fascinated, while Brown and Varju set the observational instruments in order. It seemed to oscillate slowly in shape, from oblate to prolate and back, and at each orbit the knot of swirling energy at the edge of the event horizon seemed to be brighter than ever. And it continued to brighten.

Not brighter, I suddenly realized. Closer. Approaching the orbiting station. Perhaps it was the triggering of the faster-than-light engines. Could a gas cloud attack a ship? I didn't know. Could the others see it? I didn't know that either.

The constant, low throbbing of our engines suddenly stopped, and the warble of various alarms sounded through the station. Varju and Brown swam over to their consoles. "What was that?" Brown asked.

"Sudden overload on the power system," the pilot replied. She was at a computer console, connected to some diagnostic routine on the ship's electrical systems. "Propulsion systems shut down automatically. I'm reading no detectable damage to the engines. They just won't put out power."

"What caused it?"

The pilot shook her head. "I don't know. I just don't know. The life sup-

port systems are still operational. We're down but we're not dead." She unbuckled from her jump-seat, pushed off from the deck with a spiraling upward leap, grabbed onto a go-bar and pulled herself headfirst into her piloting egg.

"Varju," said Brown. "What's going on?"

Varju was frantic on his station, flicking the screen from one camera to another faster than I could even recognize the image. He shook his head; another gesture learned from the humans. "No information."

"Any signs of life?"

"Negative," said Varju. "Unless the energy field itself is alive." He paused, then continued, slowly. "A life form that evolved around a black hole would be very different from anything we know. They would have very different perceptions of space and time."

"Is there anything on the radio?"

"No."

"Let's try transmitting." He waited while I brought the high-gain antenna on line. "Ready? OK. This is Jared Brown of the Earth starstation *Igloo*. Is anybody there?"

"Nothing." It amused me that he seemed to expect that this thing, a thousand light years away from his home planet, would be able to speak and understand English.

"Varju. Anything?"

"High graviton flux in the energy field, showing unusual ordered flux patterns. Coesive binding of a low entropy state . . . sir, this energy field may display signs of intelligent life."

"Try another frequency. Try several frequencies." Brown waited while Varju patched the system.

"Is anybody there? We're in trouble. Is anybody there?"

A voice suddenly spoke. The intonation was unusual, but it was easy enough to understand. It was in the human speech, English.

"Human Brown. It is . . . strange . . . good to see you once again."

I abruptly recognized the voice. The overtones were different, but the rhythm was identical to the first mate's own voice.

"Identify yourself. How do you know me?"

Working furiously, Varju put something on the screen, perhaps the visual track from the radio signal. On screen it showed as a complex network of colored light surrounded by a glowing aura that wavered frantically.

"Names are of little significance to me," the voice said. "Call me . . . the one who stands outside. Or, perhaps, the one who loves life."

"You have damaged us," said Brown.

"I do not think you realize exactly how much danger you are in."

"We are well aware of the dangers of black holes, thank you. We have no intention of approaching too close."

"That is the danger." Surprisingly, the voice laughed. "No, Mate Brown. I am only finishing what you started long ago. Call it . . . giving you an opportunity."

Pilot Stakowski was in her piloting egg, but with the hatch open to the science bay. She was watching her consoles. "We may be in trouble here," she called out. "The event horizon of the black hole is oscillating, and the oscillations have been building in ampli-

tude. That shouldn't be happening. The varying gravitational field is turning our orbit chaotic." She tapped her keyboard and scanned the screen hastily. "Our orbital eccentricity is increasing. Hard to predict. If the resonance builds up. . . ."

"That is impossible," said Varju. "No possible force could generate gravity waves powerful enough to shift the orbit of a ten-million kilogram station. The energy required would be enormous."

Softly, as if to himself, Varju continued, "of course, if a life form evolved around a black hole, it *might* control enormous energy."

Brown reached for the radio, but it was already too late. I could feel the passing gravity waves now, millions of tiny fingers slowly stretching and then compressing my limbs, my internal organs.

The station made a sound like a generator revving down, and alarms began to sound as stress built up on the station's structural shell.

"It's too late," said Stakowski. Her voice was calm and professional. "On this orbit our periapsis grazes the event horizon, and I can't get the engines running. The station won't make it; we'll be pulled to spaghetti. This is it—"

The disk of blackness elongated; the boundary of blackness distorted, writhed. There was no sense of motion, and too little time for fear. I had a feeling of being stretched and compressed at the same time, and then there was a sudden sharp snapping crackle as the plasma cloud discharged against the station. The tendrils behind Varju's neck stiffened. The blur ahead of us en-

larged, and then suddenly the station was *elsewhere*.

Swirls of ionized dust motes sparkled around the station, then faded. In the viewport was a blue planet with white clouds and unrecognizable continents in brown and green against blue oceans. Far away behind it, a comet was visible against the stars.

"What the hell?" said Brown.

"Impossible," Stakowski muttered. She reset all the circuit breakers, and the lights and control panels came back to life. "Impossible . . . unless . . . no, that's unconceivable." Stakowski and Varju argued for a moment, in rushed sentences too low and clipped for me to follow. Then she turned to us and spoke again. "The only way I can figure it," she said, "is the gravity waves. It seems impossible, but a gravity wave could have exactly canceled the tidal distortion of the gravity field as we skimmed the surface of the event horizon and prevented us from being torn apart. It's possible in theory, but . . ." She paused. "Well, anyway, it is possible in theory."

"But where are we?" asked Brown.

She shrugged. "Could be anywhere. In a gravity field like that? Spacetime is unstable." She checked her instruments. "A type G two star, main sequence. Seven major planets plus planetoids visible, maybe more on the other side of the star. One of the planets is an Earth-sized world with a breathable oxygen/nitrogen atmosphere."

Varju had been looking at his instruments as well. He looked up at Brown. "I can't calculate our galactic location. The computer can't match the star patterns with the standard galactic refer-



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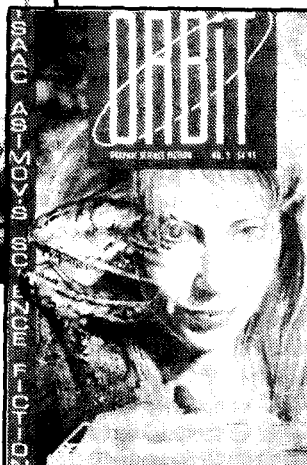


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ence beacons. I'll try initiating an extended search of the data base."

"Good. Keep searching. Mr. Torri: has the energy . . . thing followed along with us?"

"No," I said.

"Any engine power at all?"

"Engines work fine," said the pilot. "Came back on line like it had never been out when I reset after we hit the hole." Not that that would do us any good. Only the core ship had the FTL drive. If we weren't there to be picked up. . . .

"Good," said Brown. He opened a drinking tube and took a long, slow sip of diluted ethanol from the supply he had brought with him on board. It seemed to calm him. "So, get us into orbit."

The planet was much like our pod-home, much like the humans' Earth, although the land masses were strange, with elongated continents straddling the north and south rotational poles, and island continents in the ocean between them. Behind it a huge comet shimmered with the cold, faint glow of hydroxyl ionizing in a stellar wind.

Brown stared out fixedly. "That planet," he said, his voice seeming puzzled. "Something . . . it looks oddly familiar."

Varju looked at him with interest. "Have you seen this world before?"

Brown shook his head slowly without taking his eyes off the viewport. "No. No, but still . . . something . . . the color, the clouds . . ."

"Sir?" said Pilot Stakowski.

He shook his head as if to clear it. "Yes?"

"Sir, there's something else peculiar about this system. If you look at the screen—" She touched her keyboard. An image of orbits of the various objects in the solar system showed on the main viewscreen. Five were parabolic orbits originating far away from the sun. "You see that there are currently five comets in the inner solar system."

"That's a very unusual situation," said Varju. "Normally one would expect to find at most one comet, or perhaps two, in the inner solar system at any one time."

"What of it?" said Brown.

"Well, this comet here—" The pilot paused.

"What about that comet?" said Brown, his tone indicating irritation.

"The trajectory," Stakowski replied. "It's on a direct course toward the planet."

"How long until impact?"

"About thirteen hours," Varju replied.

"Is there life on the planet?"

"Life is abundant on the planet," said Varju. "No signs of intelligent life, though."

"A tragedy," said Brown, "but what does it have to do with us? Torri, do you think we can destroy the comet before impact?"

I worked for a moment at my station, which included full diagnostics on what insufficient weapons the human station had. "No. If the engines operated, we could try to nudge it off course. Without engines, nothing."

Varju spoke up. "Sir. Observe. Here, on the big continent." Varju brought up a display on the main screen. The planet showed as a grid on the

screen. As Varju manipulated his console controls, the image rotated, and one area was magnified until a contour plot showed at a location near the center. A cross-hair grid blinked to mark the center of the contour. "This is an infrared telescope view, but microwave or millimeter contours look the same. A complex energy field. Just one. And this is not an exact match, but it is in many ways similar to the energy anomaly at the black hole."

"Anything on the radio?" said Brown. "Any attempt at communication this time?"

"I worked at my station. "Nothing. No radio emissions of any kind except solar static."

"Apparently if we are to leave this place," he said, "we will have to meet the phenomenon. Stakowski?"

"The area is mostly jungle," she said. "There is a clearing roughly two kilometers south-east of Varju's energy field far enough to land the station."

"But do you think you can get this pig of a tank out of orbit and land it without breaking anything?"

"Sure," she said.

"He struggled. Then do it."

When the station had landed and the disturbance of the landing engines died out, Brown and I got ready to exit while Varju scanned the area. A team of three, one of each species on board. The pilot remained in her egg; she would stay there until we were safely back in space.

I checked my weapon, a small plasma beam rifle. It was not really suitable for an unknown planet, but the humans explore with a lot of disregard for safety, and tend to look askance at larger weap-

only carried by those on their science ships. They are the most dangerous animals on their own home planet, and expect no danger from others. Except other humans.

Brown had no weapons, but carried a large radio to communicate back to the station (we all had suit radios as well, of course) and Varju carried an assortment of scientific equipment.

"Looks clear," said Brown. "Atmosphere should be OK if there's an emergency, but we'll keep suits on. Ready?"

We were ready. Varju opened the lock, and we jumped out onto a new world.

We had all been on landing teams before, and knew what to do. We had landed at the edge of a forest densely green with ferns and odd towering trees. Varju stepped out and surveyed with his instruments. I waited a moment to see what would happen to him. Nothing. I jumped down, ran flat out to a spot where I could see around behind the station, crouched down, and looked frantically around me, my weapon drawn and ready. I wished I could smell the air for danger, but of course the suit prevented that. Brown stepped out calmly and looked up at the comet, which loomed huge and cold in the pale blue sky.

Varju continued surveying with a gas chromatograph. "Earth-like, a bit higher carbon dioxide." He put down the instrument. "Seems to be hardwood forests. Very few flowering plants." He looked in the opposite direction. "Some sort of large animals in the vicinity. I think."

Suddenly even I could hear the crashing. A gigantic reptilian head on a

snakelike neck suddenly poked out from the trees.

I instantly aimed my weapon. It was only a small plasma beam, but a well-aimed shot might disable the beast and save our lives.

Brown shouted. "No!"

As my weapon discharged, Brown knocked my arm aside. The deep blue bolt skewed off to the side. No time for a second shot. Brown and I held absolutely still.

The animal—whose head alone was as large as both of us—dipped its head down to look at us, cocked its head quizzically to the side and looked with one tiny black eye, then the other. After a long moment the beast snorted, and the head withdrew back into the underbrush.

"Herbivore," said Varju calmly.

"A lucky guess," I said. This was a survival issue; I was angry. "First Mate Brown, why did you deflect my shot?"

"Because I recognized that animal!" said Brown. "Varju?"

"Quite right," said Varju. He, too, seemed to know something I did not. "One of the saurischians, the largest land animals ever to exist on the planet Earth. Alamosaurus, judging from the size and the shape of the head. Indigenous to the late Cretaceous period of Earth history."

"Then this planet is—"

There was an attention beep from our radio link. Brown flicked it on.

The voice on the radio crackled, but the tone of fear in Stakowski's voice came through clearly. "I've identified the star pattern from the computer archives!" said Stakowski. "I know what has happened! We have been displaced

backward in time nearly seventy million years."

A buzzing sound. I turned my head to follow the motion of an insect.

"The planet we're on is the Earth."

The insect landed on my shoulder. It was a very large insect, perhaps a poisonous one. I raised my hand to squash it.

"Don't harm any animals you encounter! A change in history at this point could have severe consequences millions of years hence."

I stopped suddenly, and gently bushed the insect off my shoulder.

Brown pushed his mike to transmit. "Yes," he said dryly. "We've figured that out."

We all put away our weapons.

Brown looked at a compass. "This way, I think."

Varju looked toward the comet. "Sixty-five million years in the past."

Brown raised his eyebrow. "Yes?"

"And that comet," he gestured, "will impact in twelve hours. The catastrophe caused by the collision will cover the planet with a thick cloud of dust and smoke. The freeze will destroy every life form on the planet larger than a *vraln* . . . larger than a rabbit. It will wipe the slate clean. And give your species a chance to take over."

"So this comet will spell an end for the dinosaurs," I said. I knew what dinosaurs were. I had studied. I had studied the history of the humans, my strange but amiable hosts, and of their planet.

Brown nodded. "And a beginning for us."

My companions puzzled me. Space and time are the same, and in principle

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we all knew that if space flight is possible, so also must be travel in time, but the reality hadn't seemed to disturb them a bit. First Mate Brown apparently had no fear at his position; no sense of impropriety at being co-located with the ancestors of their most ancient pod.

Onward, said Brown.

We trod in the direction Varju indicated, through thick underbrush toward distant trees. Behind me, I could see Varju scan with his various scientific instruments, occasionally pausing to examine areas of unusual interest. Despite the demonstrated danger, he seemed not to be especially watchful.

"This planet is not unlike parts of the my home world," I said. And just as dangerous to the unwary, I thought, but kept my thoughts to myself.

"You have animals like *that*?" said Brown.

"No, quite so large. First Mate Brown. But a bit more ferocious."

Varju was still scanning the area, oblivious. Without looking up, he said,

"This is a magnificent opportunity to observe biosphere evolution—"

Just then there was another call from the ship. Pilot Stakowski had found something she thought was of interest, and wanted Varju's opinion.

We found a little wall of mostly bare rock, which I figured as probably the most defensible position we could have. Brown set up a portable video screen.

"I ran a calculation," Stakowski said, "based on the hypothesis that the cluster of comets we observe fell into the Solar System because of the perturbation of the Oort cloud by some massive object. Based on the results of the calculation, I computed the probable

current location for the object and conducted a search using the long-range telescopes."

"And?" asked Brown.

"It's on the screen." The view was of empty space with scattered stars, evidently a computer-enhanced telescopic view. A blinking rectangle in the center indicted the search location.

"Well?" said Brown. "I don't see anything there." There was a pause. "I see. A black hole?"

"I think so. Similar to the one in the Praesepe Cluster, perhaps slightly less massive."

"And you believe they may be one and the same?"

"Well . . . a black hole *would* be expected to gain in mass over time."

"Can we use this to get the *Igloo* back to our own proper time?"

"Negative. Tidal forces near the event horizon would tear the station apart. In any case, without FTL drive, it would take twenty years to get there."

"Hmmm," said Brown. "Well, carry on with your work." Brown folded the video and the umbrella antenna back into their box, and we continued on.

Varju paused and frowned in concentration, tendrils stiff, scanning each side of the path. "Interesting," he said. He shook the machine and looked at it again. "I seem to be detecting a—"

A low resonant note, a sort of booming, vibrating warble, came from behind the treeline. I pivoted and reached for my rifle, then deliberately let my hand drop to my side. It was an order of pod survival to kill nothing here. The human pod, to be sure, but survival of an ally pod takes precedence over any

individual, no matter what. At least until the alliance is dissolved. I searched for cover.

"What was that?" said Brown.

"Hadrosaurs," said Varju.

I could see their body heat reflected off the tree leaves before I could see the animals themselves. They slipped out from between the trees with amazingly silent footsteps for animals so large, a herd of fifteen of them.

"I'll be damned," said Brown. "Duck-billed dinosaurs with purple leather capes. Now I really have seen everything."

They ran past on two legs, twice as tall as a human, running with a curious rolling motion, heads down and necks stretched out ahead of them. The "capes" were a flap of skin, fluttering from a flagpole-like crest on the head and stretching loosely back to the shoulderblades. The hadrosaurs did not even spare us a glance as they ran past, blood pulsing hot patterns across their skin. They silently vanished into the forest behind us. They were fast, and in a moment nothing was left of them but the swirls of heated air from their labored breathing.

Behind them the woods still rustled. "And apparently also a large theropod," said Varju.

"A what?"

The warbling roar repeated, and branches shook. A tree crashed forward into the clearing where we stood, and suddenly a gigantic hot-blooded shape loomed up half-visible behind the trees.

In a moment the huge head rose up above the highest branches of the tree-line. This was no gentle plant-eating reptile. Even my inadequate knowledge

of extinct Earth animals could recognize this one. It was the king of the giant lizards: a tyrannosaur. It turned sideways and a huge eye looked down. The mouth opened, showing large daggerlike teeth, and the dinosaur roared again.

Brown and I looked up in awe.

"A large, carnivorous dinosaur."

"Don't shoot!" shouted Brown. "Run!"

The dinosaur's shadow fell over us. We turned and ran. With a loud crash, another tree shattered and fell. The roar repeated. I looked behind me. The beast stood motionless on top of the fallen trees, its head turned sideways to watch us.

We ran. A large boulder blocked the path; Brown cut to the left around it; I and Varju dodged to the right and through a narrow cleft in the red sandstone cliff face.

The tyrannosaur looked to the left, saw Brown, and with a jerky motion slued around to follow. It moved with incredible swiftness for a beast so large, running with its tail stiff out behind it and its back almost horizontal.

I scrambled up the rock face and turned to look back. From my new angle it was clear that the other path came to a dead end at the face of the cliff, with no convenient niches to hide in and rock walls too steep to climb. I stuck my head out to look for Brown.

He looked left and right, but saw no escape. The shadow of the tyrannosaur rose over him. He looked up.

The tyrannosaur pivoted its head down.

Brown stood frozen on a large rock, his bubble-helmeted head eye to eye

with the tyrannosaur. The head of the beast was nearly as large as Brown. He stood perfectly motionless, and the tyrannosaur sniffed at him, then opened its mouth, showing pointed, six-inch long teeth. A snakelike tongue darted out of its mouth and licked him, once, twice, again. With a disappointed querulous noise almost like a meow, the tyrannosaur spun around in a single graceful movement.

It hopped onto a high rock outcropping, raised its head, and puffed out its throat sac. Then it sang out, with a long, low warbling note that trailed out into a trilling coo. It cocked its head and listened for a long moment, but only silence greeted it. It hopped to the ground and vanished into the forest.

Varju and I came up behind Brown and stared after the retreating dinosaur. My hand repeatedly reached toward my rifle, but stopped without drawing the weapon. I did not understand.

Varju explained calmly, "It detects its prey by scent. In the suit, Brown had no smell, therefore, he was not prey. When it realized he was not edible, it lost interest."

"Never would have figured it," Brown said, still looking after the vanished animal. He seemed unshaken by the encounter. "Never. Who'd have thought a tyrannosaurus would have gold and brown spots like a leopard?" Brown shook his head. "Onward," he said.

We continued around the boulder. The radio sounded, and the first mate stopped, unfolded the umbrella antenna, and turned it on. "Brown here."

Pilot Stakowski was audible over quite a bit of static. "You're entering

the vicinity of the anomalous energy field," she said. "I can still pick up your signal, but may not be able to get through to you."

"Are you suggesting that we turn back?" asked Brown.

"No," she said. "No point in that. Just . . . be careful."

"Will do," said Brown. "Out."

I looked up into the sky as Brown folded up the antenna. The comet hung suspended against the blue. It seemed to have grown larger than ever.

We continued on.

We continued over a ridge and looked down into a valley. Varju's anomalous energy field was a fuzzy blob of light drifting slowly in the air, a fine network of webbing slowly moving inside it, glowing with light but no heat.

Varju scanned it, and shook his head. "Strange. Interesting. Highly organized energy fields. The intensity is remarkable."

"Is it alive?" asked Brown. "Is it intelligent?"

"Is it dangerous?" I said.

"I don't know," said Varju.

The energy field glowed brighter, and a voice spoke. "Greetings, travelers." I was surprised. Could I have heard it correctly? It was not the human's language; it was my own. I turned to translate for the others, but they understood it as well. What could speak three languages at once?

"This planet is dangerous," it said. "Why have you come?"

Brown shaded his eyes against the glare. "We are peaceful travelers who have been sent here by accident. Who are you?"

"Names are not important. I am one who watches and loves life. Call me . . . the Outsider."

The energy field again glowed brighter. I grimaced and dropped into a combat crouch. Brown dropped down onto one knee, his right arm shielding his face. Varju stood and did nothing. Apparently his eyes were less sensitive to extremes of brightness.

"Does my brightness harm you?" the energy thing said. "It is not something under my conscious control. I will try—" It flickered and then dimmed a bit. We could look in its direction again, although with some difficulty.

"What are you?" said Brown. "What do you want with us? How do you speak our language?"

"I cannot 'speak' any language," it replied. "Your brains contain electromagnetic fields. I modulate these fields, and you perceive it as speech."

"Why are you here?" asked Brown.

"I could ask the same of you," it said.

"But this is not your world."

"No," it said. "I am . . . an observer. My form is not one that evolved on planets, or has much interest in planetary life. We come from the energetic regions at the galactic center, where organic life types such as yours do not survive."

"From a black hole?" asked Varju, still trying to satisfy curiosity, when he should be asking the being to return us to our proper time. But I stayed silent. It might yet be that gathering information would prove useful.

"Ah," the energy being said. "You understand us."

"Then you may be extremely old, as

we measure time," Varju said.

"Millions of years," it said. "billions, who can say? Time has little meaning where we live. For several millions of years I have been wandering the stars of the galactic disk, visiting the cold dark wastes at the fringes of the galaxy, observing the strange life that grows on planets, cold and hard."

"A scientist, then, like we," said Varju. "Are there many of your people here?"

"Oh, no," the thing said. "Only I. For the most part, my people have left this spacetime. There are other places to exist, universes with higher quantum energy states, and my people have migrated on. Someday I will join them, but not yet. Even in a million years, I still have not tired of the infinite diversity of life. This is one of the most unusual worlds I've visited."

Brown smiled. "We like it. This planet is my home."

"Indeed?" it said. "Very peculiar. I would not have come, had I known that this planet had intelligent life. But was that not your starship I sensed arrive here?"

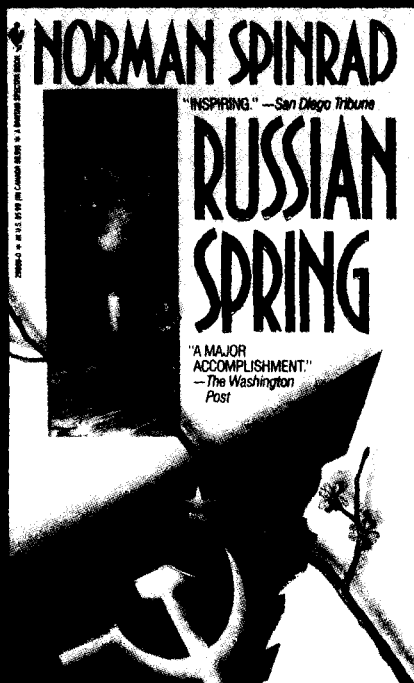
Brown looked at Varju. "That's right," he said. "We have come from sixty-five million years in the future."

"Really?" said the Outsider. "You come to your own past?"

I noted that it didn't seem surprised at the impossibility that Brown had just expressed. Perhaps, as Varju had implied, this being could indeed tread paths through time as well as space.

"You have no fear of the danger of returning to your own past light-cone? Or—yes. You are here because of your fear. It is unnecessary. I will correct the

"Inspiring."



1. *San Diego Tribune*
2. *Kirkus Reviews*
3. *Omni*
4. *Library Journal*
5. Orson Scott Card, *The Magazine of Fantasy & Science Fiction*

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error."

"Error?" asked Varju.

"Why," a tentacle of brightness momentarily flashed upward toward the comet. "that comet. You must be here to stop it from impacting this planet, stop the great destruction. I shall put it back in its proper place. I would not let this beautiful world be destroyed."

"No—" said Brown. "the comet hit sixty-five million years ago. Far in the past. If the comet is deflected, the human race—my race—will never exist."

"What is that to me?" the being said. "I have made my decision. I see no reason to destroy the cold beauty of this world."

"But it is the natural course of events," said Brown. "Evolution."

"You put me in a dilemma," it said.

"You see, I already *have* interfered with events. Only my interest in planets caused the black hole to approach this sun. No comet would be here, if not for my error."

"That accounts for the unusual features of the system," Varju said. "An artifact of the passage of the black hole."

"By diverting the comet," it said, "I will only undo the damage that I inadvertently caused."

"And so destroy us," said Brown.

The being made a complicated flickering shift of brightness that I interpreted as a shrug. "What does not exist cannot be destroyed. You are from a future, but not the only possible future. I will merely cause your species never to exist."

"Never to be born at all," said Brown. "But however you phrase it, it still sounds fatal."

"You must understand that you do not really exist. You are only a virtual apparition. A side-effect of the small interval between when I perturbed the comet cloud and when I correct my error.

"For one to live, others must die. This is the law of life."

For a moment the Outsider brightened and was silent, a shifting blur of mottled colors. The tendrils behind Varju's neck, his electromagnetic sensor organs, stiffened.

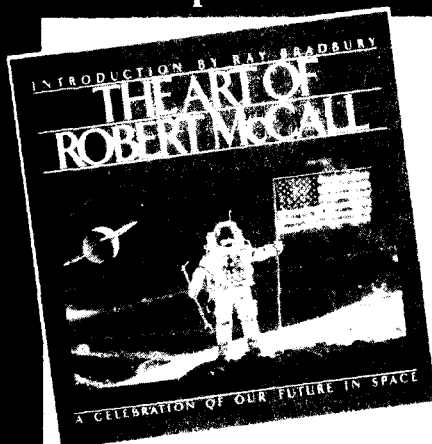
It made a soft sound almost like a sigh. "What being would not choose survival of its own species? So you force me to choose." It paused. "So let it be. If you would have me choose you to live, prepare to argue your case. Human Brown, you have with you two others who are not of your species. I name you my council of three, to convince me to change my mind. Be warned. Your vote must be unanimous if I am to condemn this planet.

"You come from the future. One future. I will show you another, the future that you would have me kill."

The glow of the energy-being momentarily brightened, and we were forced to look away. When the brightness dimmed, we saw before us another creature. It was a reptilian being, seated behind a desk of some dark heavy wood, writing with what appeared to be a quill pen. It was roughly the size of a human. It was clearly similar to the dinosaurs we had seen, sitting upright, with a long tail visible to one side. It turned, and I saw that it had a smooth, sinuous grace. It had light-green skin, appearing almost silky, lighter on the underside, patterned with delicate trac-

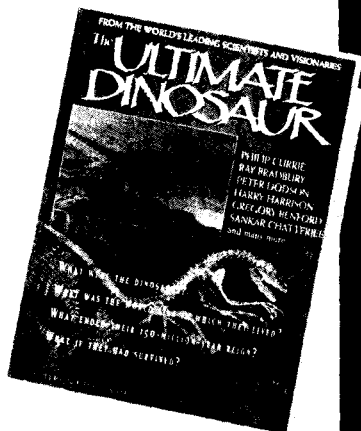
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eries of light orange and yellow, and a ruffle of feathers behind its neck. Its eyes were large and blue, like gigantic sapphires, with small half-glasses perched on its nose. It looked up from its work and peered over its glasses.

"You interrupted me," said the dinosauroid being, peevishly. "I was in the middle of a stanza, and you interrupted me."

Brown smiled. "Sorry."

It waved a clawed hand. "No matter. This symphony has waited all my life; it can wait a bit more. Perhaps it was time for a break anyway." The dinosauroid looked around, then stared at Brown, turning its head slightly to look first with one eye, then the other, cocking his head exactly the same way the earlier dinosaur did. "Good gracious! I've never seen anything like you. What manner of beings *are* you, anyway?"

Varju turned to Brown. "This is unusual. It seems to have no xenophobic response at all."

"Is that unusual?" I said.

"Yes," said Varju, turning to look at me. His eyes did not blink. "We had always believed that xenophobia was a survival instinct."

"But—but your own species has no xenophobia," I said, confused. "I've seen you with humans. You emulate them. You speak their language. think with their thoughts."

Varju looked at me with large, sad eyes. "Do you not know? You have studied the history of the humans, do you know nothing of mine?"

"No."

"When we met the humans it was war, Torri. We studied the humans, studied their aggression, studied their

technology, and realized that we could not possibly win. Within a century, we would be exterminated. But xenophobia—war—was encoded in our genes. Our only survival lay in revising our very genetic code. We did. We edited out our xenophobia, and surrendered to the humans, asking only that they give us protection, since we could now no longer protect ourselves." He paused. "Don't you know how we admire your race, Torri? To survive side by side with humans, and remain yourself?"

And the humans had cost us a hundred billion lives, I thought. Could it be worth the price?

"Ask your questions," demanded the energy being.

"What is your home like?" said Varju.

"It is a home place like any other, I expect," the dinosauroid being said. "It is warm and friendly. We do what we can to make it beautiful, with gardens and forests."

"You have no cities?" Varju asked.

"No, no, of course we have cities. The best artists in the world compete to design our cities. Towers of shining crystal ten kilometers high . . . I wish I could show you one of our cities, they are so beautiful."

"Do you have wars?" Varju asked.

"War?" said the dinosauroid being. "I don't recognize the word."

"Do you kill one another?" said Brown.

"Kill? You mean, kill other intelligent beings? Deliberately? What a revolting thought! Good gracious, no! Of course not! What type of beings would do such a thing?"

Varju and I exchanged glances.

then this human, a child of a different possible future, cannot."

"My mate . . ." said the dinosauroid. "My friends and clutch mates . . . my children—"

"Will never exist," said the energy being. In a more kindly tone, it continued, "they will not suffer. They cannot suffer, since they never existed at all."

"Then let me tell you about my grandchildren," the dinosauroid said. "Such a cute bunch of lizards you'll never see. Little rascallions, really . . . but we love them. Moru—he's the oldest—he says he wants to be a famous composer, just like his grampa. I keep on telling him that if he wants to be a musician, he has to be diligent and practice every day, but he'd rather be out playing Vorik ball with his friends." It shook its head with a jerky circular motion. "Ah, children. Well, there will be time for practice when he gets older. Let him have his fun. The little one, Kira—she's the youngest—barely out of the shell, and already she knows what she wants to be. Says she's going to be the pilot of a starship when she grows up. And I bet she will, too—she's smart enough. And so serious all the time." It stretched out its neck and sighed. "Too bad you will never know them. But please try to think of them, one day, and they will live on, a little bit, in your memories."

"I will," said Brown.

"You have starflight?" asked Varju.

"Oh, yes—ever since the spacetime twist drive was discovered two millenia ago," it said. "I don't see the point in it, myself—all that whooshing around through space. You'd think saurians would be satisfied with the Earth—it's

a lovely planet. I've traveled up and across and around, and don't think I've seen a tiny fraction of the wonderful things there are to see."

"Plead your case for your people," said the energy being.

The dinosauroid examined Brown closely. It shook its head again with the same odd circular motion. "A featherless life-form—descendant of mammals—and yet from Earth! Most strange. But your people, too, love life?"

"Yes," said Brown.

There was a long silence as the dinosauroid looked at Brown. Then it said, "I cannot. If our existence is to be at the expense of another, it is wrong. Make your choice, if you must. I cannot and will not urge the destruction of another."

"Well spoken," said the energy being. "And so I return you again to the might-become."

"I regret only—" the dinosauroid said, and hesitated.

"That you are not real?" suggested Varju.

"No. I accept the gift of life, however temporary. I regret only that, now, I shall never complete my symphony." It paused. "And so I see it is true. Of all sad words of tongue or pen, the saddest are: it might have been."

The energy being brightened, and when we could look again, the dinosaur being was gone.

"John Greenleaf Whittier, an Earth poet of the nineteenth century," said Varju. After a pause, he added, "and also, apparently, a dinosaur poet."

"You must understand," said the energy being, "that you are no more real

than the dinosaur being. You claim to come from the future, but you must know that there are many futures, none of them more real than any other. This is the now, the only now that exists. Make your choice wisely."

"Then you have shown us a possible future," said Varju, "but by no means the *only* possible future."

"Quite correct. But what I have shown you is the future that will result, if I do not allow these creatures to perish."

"I know the humans," said Varju. "They have flaws. But they also have a greatness. I must vote for the humans."

The energy flickered, and I felt its attention turn to me. "And you?"

I suddenly knew that with words I could change history, undo great pod dyings and challenge greatness. This being had power, great power. I had fear, then, and knew I must choose words with utmost care. "When my race met the humans, we had no faster than light travel," I said. "Our pods had spread across a hundred suns, at tremendous cost, but without war. When the humans with their FTL ships came, we welcomed them with weapons. The humans seemed to withdraw, and we copied their ships, a technology we would never think of on our own, to unite a hundred far-flung pods."

"And then we were hit by the plagues. Fifty billion of the true people died in the plagues that the humans brought. We thought, then, that they had deliberately tried to destroy us."

Much, much later, we realized that it was not the humans, but their technology, FTL travel, that killed us. The hundred worlds had evolved a hundred

plagues, each of which they were themselves immune to, but the distant worlds were not immune. Century-long starship voyages acted as a quarantine.

"And after the plagues, the civil wars. Among the hundred scattered worlds were renegade pods, unwilling to join in sharing. They had been separate too long. The human FTL brought us a new thing, war between pods. Whole worlds had to be exterminated to bring unity back to our people. In the chaos, prophets and messiahs rose up, preaching heresies and disunity, and more of us died."

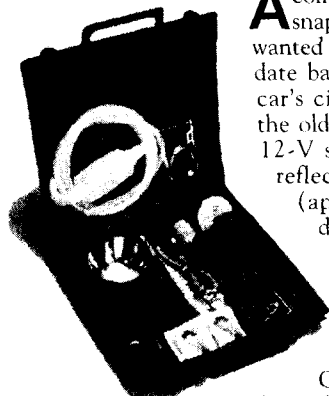
"The coming of the humans resulted in the death of eleven out of twelve of the true people then alive. Even the rooted ancestors died. Out of the hundred worlds, only sixteen flourish now. It will be centuries, perhaps millenia, before we reach such glory again."

"Then you vote against the humans?" it said. Its voice seemed cold and emotionless.

And so in my moment of *timra* I embraced choice. I shouted. "No! The humans taught my people things we never dreamed of! Without having met the humans, we would have expanded outward and outward, knowing ourselves only, exterminating other species on planets we needed, without ever knowing or trying to understand them. Until one day we would meet an alien race with superior technology, who would exterminate us the same way. We were lucky. When we met the aliens with superior technology, it was the humans. They nearly exterminated us, true, but not in anger. They taught us how to embrace the alien. I vote for the humans, hidden one. They taught us a

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concept alien to us, one that is worth anything we ever knew before. Friendship, between people who are different."

I spoke the truth, but my spoken reasons screened the truth. The humans had killed us, yes, in the billions, but the pod had survived, and, surviving, was stronger. But the dinosaur creature had said that they, too, had the secret of interstellar flight! If the dinosaur creatures had come instead of the humans, and come millions of years earlier? How could they not, even in innocence, destroy us before we even existed? The human threat had been nothing to this, nothing.

"Then you have won your case, human," the energy being spoke. "Though it goes against my nature to allow such destruction to occur, I choose to accept the judgment of three."

"Not yet," said Brown. His expression was strange; unreadable. "You said it must be unanimous."

"Indeed," said the energy being. "There is one more vote. I would have thought it just a formality. Human?"

"It's not like dying, you say. No pain. No mourning. It would be never to exist at all." He smiled. "I like that. Humanity's not so great. Give the critters a chance, and see what they do. Divert the comet."

I might have killed him, but would it change the choice? Would the being then come for us? I hesitated. The energy being dimmed and was motionless for a moment, and then the moment for choice was past.

"You have made your choice, and chosen against your own interests." It

paused. "But you have shown a strange compassion. I have seen this in old species, ones with a history of a million years or more, who have no fear of extinction. But in a young species? I do not understand this, but it is strange; rare and precious. I find that I have no choice. I will withdraw my interference. The comet will fall as it must."

"But—" said Brown.

"I have made my decision," the energy being said, its voice like low thunder. "Your species will have its chance. Use it well. Perhaps we will meet again, millions of years hence. Goodbye." With a rising sound that quickly became ultrasonic, the energy being shrank and brightened. It continued to brighten past all bearable levels, until I wondered if the very rocks it hovered over would melt. As even Varju shielded his eyes and dropped to his knees, the energy condensed into the smallest of tiny sparks, and then accelerated off into the sky.

It was a long walk back to the station. We met no dinosaurs.

We returned to orbit, and none of us were surprised when the station was again pulled into the event horizon of the black hole. We again looked into the black depths of the Praesepe Cluster.

When it was clear that we had returned and reached a stable orbit, Stakowski cracked out of her piloting egg and confronted Brown. "Brown? Tell me, how did you know that it would spare us?"

"I didn't know anything for certain," Brown said. "It just—" he shrugged— "seemed the thing to do. At the time." He paused for a moment,

and sipped nourishment from his ethanol solution as he regarded her, then continued quietly, almost to himself.

They had so much potential. It's not like we did so great, ourselves."

Pilot Stakowski gave him a piercing look, but said nothing.

"And I still wonder . . . what would they have been like? If they had evolved?"

"I expect that we'll never know, Jared," she said. She didn't seem to be angry at what the mate had done, at the fact that one human had chosen extermination for them all.

And then the voice of the Outsider came over the radio. "Greetings again, human Brown. It has been a long time."

"Outsider?" said Brown.

"Names are of little importance," it said. "Once I took that label. This universe is expanding, growing cold. I had thought to join my fellows, but waited a little while longer, to see again the one who showed compassion. To say, in your words, goodbye."

"But you still let them die," said Brown. He seemed angry, although it was his own pod the thing had chosen to save.

"I could not save them all," it said. "But as many as I could I took away with me to a planet similar in climate, far away across the galactic disk. Among the ones I took were those which would, in time, evolve to become the being you met. To let them find their own destiny."

In the viewport, the blur of energy at the horizon of the black hole was intensifying. On the radio, the voice was fading. "Someday you will meet them. I

think. But now, goodbye."

The energy field in the viewport grew outside the bounds of the viewscreen and then faded to blackness and stars.

"It is gone," said Varju softly.

"We are done here, I think," said Brown. "It is time for us to go home."

We orbited the black hole for two further weeks, until the *City of Anchorage* returned for us, but we collected only numbers and useless facts.

On its schedule the human starship brought us back to Earth, and, later, returned to its mission of gathering useless knowledge about stars and dust clouds. On the return voyage the human crew discussed First Mate Brown's actions among themselves, and most of them agreed that they would not have acted as he had. But the first mate was not punished for his actions, not relieved from his duties, nor, as far as I could tell, even reprimanded by the captain for risking the existence of his species.

It is true: the humans embrace the alien. The wisdom of the great pod-fathers has instructed us to embrace the alien, told us that our species, the pod of all pods, must inevitably die if we do not. But I wonder, I wonder. Must we embrace the alien even at the cost of self destruction? Will we, too, one day be forced to make such a choice? And if we choose wrong?

I request to leave this mission, to return to the pod-home, share the soil with my pod-mates and meditate in warm darkness. I cannot stay among these beings that I do not want to understand.

I am learning to think like them, and I am afraid. I am afraid, yes, afraid for all of us.

Even the humans. ■

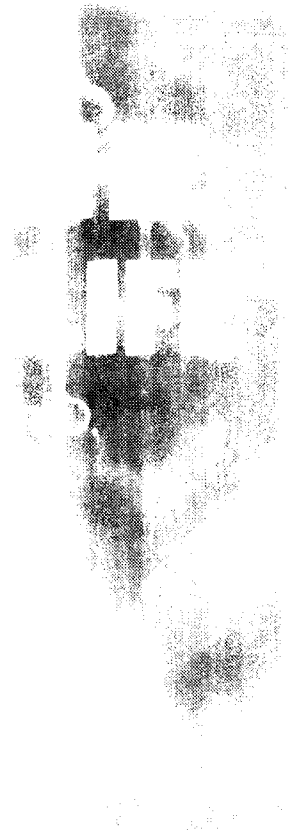


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In my formative years as a space enthusiast, back in the 1960s, I remember a classic painting of Chesley Bonestell's: it showed a crescent Saturn as seen from Titan, hanging in a dark blue sky above an icy landscape. I also vividly remember Alan Nourse's classic young-adult novel, *Trouble on Titan*. One of the delightfully right props in this story was an aircraft engine that shot a jet of oxygen into the methane atmosphere. Both conceptions were based, of course, on Gerard Kuiper's discovery of methane in Titan's atmosphere, back in 1944. One of Isaac Asimov's SF mysteries was also based on Titan's methane atmosphere. As I recall, the murderer was caught because he had first painted catalyst on the wrong gas tank: an oxygen tank.

The Mercury-sized satellite with the methane atmosphere: it was a compelling vision, but (as was so much conventional wisdom about the B.S.* solar system) it was wrong. (Titan's not even the biggest satellite in the Solar System any more; Voyager showed that Ganymede's radius is 70 km longer.) But for once the real Titan may be even more exciting than the fictional version.

For in retrospect there was no reason to suppose that Titan's atmosphere is just methane . . . and in fact it's not. In fact, most of the atmosphere is not methane. It just happens that methane absorbs several wavelengths of visible light well, out in the red. That makes methane easily (well) relatively easily, anyway) detectable with classic spectro-

scopic studies such as Kuiper's.

Lots of gases, though—including some very common gases—do not absorb in the visible. Nitrogen and oxygen, for example. You can tell this from our own air; it's clear! (Chemistry books will tell you that methane is colorless, too. But it's colorless only in very small thicknesses. In fact, if you look through a lot of methane gas, the light will look distinctly blue. The blue color of both Uranus and Neptune results from absorption of red light by the methane in their atmospheres.)

Restudy of Titan back in the early 1970s suggested there was lots of additional gas in Titan's atmosphere. Spectroscopic absorption lines can be broadened out slightly by the total atmospheric pressure, and such "pressure broadening" seemed to be present on Titan. Titan's air couldn't all be methane. In fact, it couldn't even be mostly methane. Something else was there too.

What is most of Titan's atmosphere, then? Nitrogen. Lots of nitrogen. See the Table. Titan has an even thicker atmosphere than Earth: at 1.5 bars, it has about twice Earth's complement of N₂. This, of course, was firmly established by the Voyager 1 flyby, back in 1980. (Earth, of course, has ≈ 0.8 bar N₂, with most of the rest oxygen. A bar is a unit of pressure almost equal to one atmosphere.) As Titan's atmosphere also thins out more slowly with height than Earth's, due to Titan's low gravity, Titan has an impressive atmosphere indeed. Arthur Clarke's *Imperial Earth* was probably the first story to use the

*Before spacecraft!

Titan's Vital Statistics
(Data from Hunten et al., 1984)

Radius (kilometers)	2575
Mass (Earth = 1)	0.022
Surface gravity (Earth = 1)	0.14
Mean density (g/cc)	1.88
Orbital distance:	
from Saturn (millions of km)	1.226
from Sun (AU)	9.546
Orbital period:	
around Saturn (days)	15.95
around Sun (years)	30
Axial tilt (degrees)	26.7
Surface temperature (kelvins)	94
(degrees C)	-179
Albedo (Earth = 0.33)	0.20
Incident sunlight (Earth = 100%)	1.1%
Surface pressure (bars)	1.5
Atmosphere composition (of lower atmosphere):	
Nitrogen (N ₂)	65-98%
Methane (CH ₄)	2-10%
Argon (Ar)	0-25%?
Hydrogen (H ₂)	0.2%
Carbon monoxide (CO)	≈0.01%
Ethane (C ₂ H ₆)	0.002%
Propane (C ₃ H ₈)	0.0004%
Acetylene (C ₂ H ₂)	0.0002%
Ethylene (C ₂ H ₄)	0.00004%
Hydrogen cyanide (HCN)	0.00002%
Methyl acetylene (CH ₃ C ₂ H)	0.000003%
Diacetylene (C ₄ H ₂)	≈0.000005%
Cyanodiacetylene (CNC ₂ H)	≈0.000005%
Cyanogen (CN ₂)	≈0.000005%
Carbon dioxide (CO ₂)	0.00000015%

new Titan as a setting.

Earth's nitrogen is a product of life, as I'll later belabor in great detail. But Titan's is not. It probably comes from photodissociation of ammonia. In photodissociation, energetic ultraviolet light from the Sun breaks up molecules, and if the pieces include light atoms like hydrogen, those atoms can then escape to space. It's another process whose importance was largely unexpected B.S., but it turns out to have a profound effect on planetary atmospheres and their evolution.

Very little ammonia is in Titan's atmosphere now—it's just too cold. Thus, the photodissociation is most likely very old. During or just after its formation, Titan's atmosphere would have been warmer from the heat of accretion, and then solar UV could go to work on the ammonia.

Alternatively, the nitrogen may be original—"primordial." Many scientists now think nitrogen and carbon monoxide—as well as, or maybe even instead of, ammonia and methane—were abundant in the solar nebula from which the planets condensed. Although ammonia and methane should be the stable gases when there's lots of hydrogen around, reaction rates are extremely slow. So maybe much of the abundant ammonia and methane in the outer planets formed after those planets condensed, when conditions were a lot more favorable for reaction. Titan's atmosphere also contains a smidgen of CO (see the Table), and it may be primordial as well.

The nitrogen atmosphere is stable,

because nitrogen is much harder to bust up than ammonia. Only a highly energetic photon, out in the far ultraviolet (wavelength less than 100 nanometers), can break the triple bond in the N_2 molecule. (For comparison, visible light ranges from about 400 to 700 nanometers.) The Sun puts out a lot fewer of those. Highly energetic electrons from Saturn's Van Allen belt will also work, but they're also rare.

In any event, nitrogen atoms are heavy. Even when broken out, they don't escape as easily as hydrogen, because they're moving much more slowly. Even if they do escape, they're still deep in Saturn's gravity well and tend to stay along Titan's orbit. Many get swept up once more as Titan passes by again.

This leads to a problem: why, then, is methane even detectable at all? It's about as easily photodissociated as ammonia. (Of course, in retrospect this also was a serious problem with the methane atmosphere model . . . but as I said already, the importance of photodissociation was underappreciated B.S.) In fact, Voyager measured the tenuous plume of hydrogen atoms from methane photodissociation streaming away from Titan. Why is any methane left?

There must be an ongoing methane source. Methane must be continually dribbling out of Titan's interior, like air from a leaky tire. So then, what does Titan's interior look like? Let's see.

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number, because it strongly constrains how much metal (very dense) versus how much rock (not so dense) versus how much ice (not dense at all) can be there.

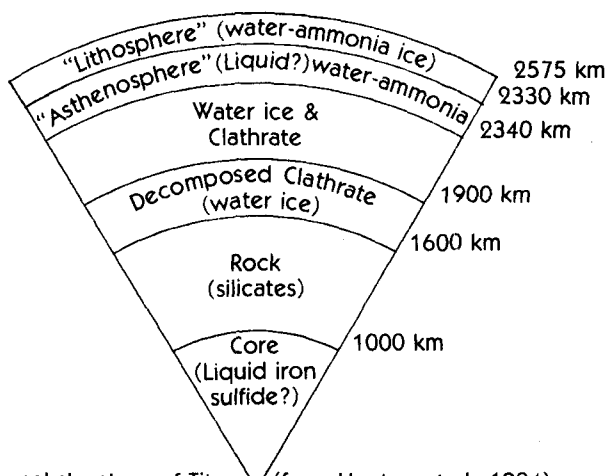
Another clue to rock content is the argon-40 content of the atmosphere. Argon-40 results from decay of radioactive but very long-lived potassium-40. As potassium ends up in the rocks (i.e., the silicates), the amount of Ar-40 that's managed to leak out into the atmosphere gives a clue to the rock content of the planet. Unfortunately we don't know the Ar-40 content of Titan's atmosphere. Ar is hard to measure, and Voyager didn't. Much less did it measure the argon isotopic composition. (The Ar values in the Table are very indirect—and crude!—estimates. Actual argon measurements will have to wait for the *next* Saturn-system probe. If the CRAF-Cassini probe ever manages to get funded, there's a chance they'll hap-

pen then.)

Still, with Titan's density only 1.88 g/cc, there's not room for much rock (or metal). (Earth's overall density is about 5.5 g/cc, due to our planet's dense nickel-iron core. Even ordinary rocks, here at the surface, have densities around 2.7 g/cc.)

Thus Titan probably has a core of rock and metal that's overlain by a great thickness of ice. One model suggests an iron-iron sulfide core about 1,000 km in radius covered by a rock layer some 600 km thick. Several ice layers, aggregating over another 1,000 kilometers in thickness, then overlie this rock layer. See the accompanying sketch. (Remember, though, we have little hard data, and the exact nature of these layers is still uncertain! So there's a bit of artistic license in the sketch.)

What do we mean by "ices"? Mostly just ordinary, plain-vanilla water ice. Water is a common compound, and it's



Possible internal structure of Titan (from Hunten et al., 1984).

abundant in the outer System. But other compounds are stirred into it, and a few other compounds (ammonia most prominently) are common enough and have high enough freezing points that they too can make up a significant part of a solid body. Hence the plural.

One type of "compound" that's probably very important in the outer System is a water-ice "clathrate." Also called gas hydrates, these are not even really true chemical compounds. Instead, other atoms or molecules are trapped truly physically engaged—within voids in the water-ice structure. ("Clathrate" in fact, comes from the Greek word for cage.) Lots of gases readily form clathrate with water ice: methane, nitrogen, carbon monoxide, noble gases, and so on. As you might expect, clathrate-rich ice was vital in bringing in other compounds when Titan (and other outer satellites) were forming. Titan's CO, perhaps its N₂, and certainly its methane arrived in clathrates. (Methane clathrates also occur on the Earth, by the way. They're found in some ice layers that occur in deep-sea sediments, under pressure, and also in some Arctic sediments. They're a possible non-traditional fossil-fuel source. In fact, terrestrial clathrates are one thing we're looking at in the lab I work in.)

But I'm digressing. Anyway, Titan's deepest ice layer, the one immediately overlying the rock, probably contains no clathrates, because they break down under too much heat and pressure. This layer may be a couple hundred kilometers or so thick. A thick clathrate-rich

ice layer, perhaps 500 km thick, probably overlies this layer, though, and it represents an enormous reservoir of methane and perhaps other gases too (see the sketch again).

A water-ammonia "asthenosphere" possibly as much as a couple hundred kilometers thick covers the clathrate-rich layer. This layer may even be liquid: a subterranean "ocean" of a eutectic water-ammonia mixture. Finally, Titan's "litho" sphere, the solid crust extending up to the surface, is probably a shell of frozen water-ammonia ice about 100 km thick. At Titan's surface temperature, this material is a rock, so "litho" is perhaps not a misnomer after all! (Water ice around 94 K is *solid*.)

Thus, Titan's ultimate ongoing methane source is probably that enormous buried clathrate reservoir. Some must trickle to the surface, venting as "fumaroles" of hot "volcanic" gas, or perhaps even bubbling out of rare eruptions of water-ammonia lava, as local heating or tectonics opens cracks in the surface shell.

Photochemical Smog and Primordial Soup

Methane photodissociation has another profound effect. When you bust a hydrogen atom off a methane molecule, you leave a highly reactive methyl (CH₃) group, which immediately gloms onto another molecule. Thus you can make more complex organic compounds, including acetylene (C₂H₂), ethane (C₂H₆), and even others—see the Table. Because of the nitrogen, you also can get nitrogen-bearing compounds

such as HCN, and reactions with the CO should give oxygen-bearing compounds such as aldehydes too, although they haven't actually been measured. Of course, as the reactions continue, you'll get lesser quantities of progressively more complex organic compounds, but they can be protected from further reaction with UV if they sink away from the edge of the atmosphere.

Such reactions have made a thick haze in Titan's atmosphere, a natural photochemical smog. For this reason we can't see Titan's surface, any more than we can see Venus's. (From the Voyager photos, you get the impression that Titan's clouds are orange. Not so; those are enhanced images. Titan's a dark object—i.e., it has a low albedo, only 20%—so it would look brown, not orange, to the naked eye.)

This photochemically produced stuff will also settle out of the atmosphere completely, as it condenses in the extremely cold atmosphere. Maybe Titan's surface is plasticky. Or maybe it looks like frozen asphalt, with eons' worth of messy organics precipitated out, as though on an old garage floor. Carl Sagan and his coworkers suggest that 100 meters of this stuff may have been formed over the lifetime of the Solar System. They propose calling such compounds "tholins," no doubt because "greasy gunk" or "yucky goo" sound too undignified. They also suggest that analysis of tholins could tell us much about the origin of life: the primordial chemicals of life, preserved in the deep-freeze of the outer Solar System. Obviously, on an active living

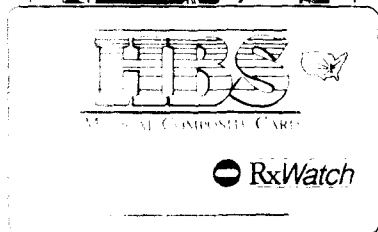
planet like the Earth, such precursors have long since been eaten!

Another possibility, though, is that Titan's tholins are instead dissolved in a frigid ocean. Pre-Voyager, some workers suggested that Titan might have seas of methane. It turned out, though, that although the surface is cold enough, the methane concentration is too low for liquid to be stable more than just locally. In other words, the methane "humidity" is too low for methane to condense. (Similarly, water evaporates on Earth, even with the temperature below the boiling point, if the relative humidity's too low.)

But there's another possibility: ethane. Ethane, being a simple molecule, is one of the common products of the sunlight-driven syntheses in the atmosphere (see the Table again), and it has a higher boiling point than methane. Lunine and co-workers have suggested that over geologic time, an ocean of ethane several hundred meters thick has accumulated on Titan. If so, it contains a lot besides ethane; many of the more complicated organic compounds, as well as both nitrogen and methane themselves, will be dissolved in it. A deep-frozen primordial soup.

Life at 94 Kelvins

But need it be a deep freeze? How about life on Titan? We have the raw materials, the CHON (carbon-hydrogen-oxygen-nitrogen) beloved by SF writers. We may even have an ocean, although it's not a water ocean. But methane has been a traditional alternative biosolvent in SF and speculative



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biology. Ethane's properties are very similar, and it should work as well.

Still, it's not real promising: 94 K is *cold*. Clearly any life under those conditions won't be Earth-like! It will need completely different sets of enzymes, and probably a completely different set of basic compounds. The compounds Earth life uses would be too stable at those temperatures. (Isaac Asimov, among others, has suggested that lipid-based compounds may be a good framework for long-chain structures, since lipids will dissolve in liquid methane because the long chains in lipids are based on hydrocarbons. Presumably life needs some sort of long-chain molecules as building blocks and to carry genetic information.)

Obviously we can't go into chemical detail at this point. But just from basic energy considerations, we can set up some constraints. What might such life do for metabolism, for example?

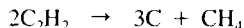
Well, obviously, it won't be based on free "oxygen". There's not enough around. And besides, we don't see any in the atmosphere.

Of course, we'll need *some* oxygen as a chemical building block in organic compounds, for such things as hydroxyl (OH) and carboxylic (COOH) groups; for ester and ether bonds; for aldehydes and ketones. Presumably one or another of such compounds will be necessary, however strange the biochemistry. But a little "structural" oxygen will be readily available, from the atmospheric CO₂ and of course the ice of the crust represents an enormous oxygen reservoir—though it might be a bit difficult

for organisms to extract.

So what could they do for a metabolism? What lots of Earth life still does: rearrange organic molecules into more stable configurations. That is, they could ferment. Primitive Titan microbes could just scarf up the natural tholins, the energy-rich, solar-synthesized compounds drifting down through the atmosphere. This, of course, is the sort of fitful fare Earth life itself had to subsist on for tens of millions of years.

Acetylene, for example, is a common product of the atmospheric synthesis in Titan's atmosphere (see the Table), and it contains energy. In fact, it's an endothermic compound, which means it takes energy to make. (That's why, by the way, it makes such a hot flame with oxygen. You're getting the energy of the acetylene decomposition as well as that of combustion.) For example, breaking acetylene down to methane and carbon:



yields about twice as much energy as the fermentation of glucose to lactic acid, a ubiquitous process in Earthly life.

Some kind of photosynthesis should even be possible, too. Rather than make sugars, microbes could instead use the energy of sunlight to make acetylene or some other energy-storing compound. This is just the way photosynthesis began on the Earth: once a class of critters could make new energetic organic molecules *ex nihilo*, using simple starting materials and the energy of sunlight, then life was no longer limited by the vagaries of natural synthesis of food-

stuffs.

Through all this the nitrogen is just a passive bystander. It contributes only in that some of the organic compounds contain nitrogen. But on Earth, a whole set of life-styles revolves around nitrogen: in fact, as I mentioned above, Earth's nitrogen is as much a product of its life as its oxygen. Left to themselves, the nitrogen and oxygen in our atmosphere would react to form nitrates and precipitate out. Lightning is always pushing this process along by forming nitrogen oxides. Only the actions of living things keep replenishing the N_2 .

Unfortunately, this isn't directly applicable to Titan. Terrestrial denitrifying bacteria make nitrogen, but they make it from nitrate ion (NO_3^-), and we won't have nitrate on Titan! It's a highly oxidized species, and these bacteria actually use it instead of free O_2 to oxidize food. They strip the oxygen out. The nitrogen's just a by-product.

Other Earth organisms break down reduced nitrogen species, but (at least usually) not to N_2 but rather to intermediates, like nitrous oxide, N_2O . Instead. And last, of course, "nitrogen fixers" complete the cycle by using energy to bust up atmospheric N_2 and incorporate the nitrogen into biological compounds.

Maybe here's a role for nitrogen, not analogous to any in Earth life: reforming N_2 from reduced nitrogen. Say, for example, we take a simple nitrogenous organic compound like hydrogen cyanide and break it down:



We get something like 128 kilocalories—plenty for a bug to live on! And

most of that comes from the nitrogen. Overall, breaking that stable triple bond in N_2 stores energy; and making N_2 releases it again.

Last, we should remember that CHON is not the whole story of life. Terrestrial life, at least, also needs other elements: phosphorus (which is vital for ATP, the energy-carrying compound in cells) and sulfur especially are needed in more than trace quantities. And you also need a smidgen of a *bunch* of elements: iron, calcium, zinc, cobalt, magnesium, and so on. Lots of these are used in the active sites in enzymes, and you're *really* going to need enzymes when it's that cold!

Such trace elements are likely to be a problem, since all Titan's rock is buried under hundreds of kilometers of ice. There should be a few such elements around: surely there will be some dissolved ions in those watery lavas, and meteorites will contribute some more. But mineral availability is likely to be much more of a problem for Titanian life forms than it is on Earth.

The Greening of Titan

Well, even if Titan's deep-frozen now, maybe we can bring it to life. It could be a candidate for "ecopoiesis": rather than implant a complete set of ecosystems, we could establish a minimum biota and let it evolve as it will.

Why bother? It's hard to believe someone would develop lipid-based life just for kicks! Even as a research project this seems extremely expensive. Maybe it would be a long shot: say, for ongoing synthesis of exotic organic compounds.

After all, the synthesis of vast numbers of compounds by living things is already a strong motivation for preserving the diversity of the ecosystems we have on Earth.

Alternatively, and perhaps a bit more plausible, maybe we could warm Titan up. Again, 94 K is much too cold for Earth-like metabolisms, even offbeat ones. Since *everything* on Earth needs liquid water, if we could get Titan warm enough that some liquid water existed, at least locally, that would make any engineering far less extreme.

As our Table shows, the sunlight arriving in the Saturn system is only about 1% of Earth's. Furthermore, since Titan is darker than the Earth—it has a lower albedo—it already does a better job than the Earth of absorbing what sunlight there is. So how might we raise Titan's temperature?

One way is a greenhouse effect. As our *Analog* readers know, this is the trapping of the heat of sunlight by gases in the atmosphere. Titan has a small greenhouse effect now—about 15 K, which keeps it above liquid nitrogen temperature. Back in the '70s, though, some scientists speculated that Titan might have a much larger greenhouse effect.

Of course, we'd need a *much* larger greenhouse effect. And one problem is that the greenhouse gases we're used to are pretty much frozen out at 94 K. CO₂, of course, is a rock at those temperatures. Chlorofluorocarbons—Freons—are excellent greenhouse gases, because they absorb much more strongly in the infrared than such things as water vapor or CO₂. See Martyn Fogg's arti-

cle in the January, 1991, *Analog* for their possible use in terraforming Mars.) But at Titan's temperatures, they all condense out! The Freons with the lowest boiling points still become liquid around 190 K (–82° C), which is a lot warmer than Titan is. Nitrogen trifluoride (NF₃), another possibility, condenses at about the same temperature.

Even methane, another trace greenhouse gas on the Earth, has problems, although it has a much lower boiling point. Of course, there's already methane on Titan, and it helps cause that modest greenhouse effect of 15 K or so. But as we've also seen, if there were much more methane, it would condense out on the surface anyway, perhaps by dissolving in the ethane ocean. Hence you can't add methane and expect it to stay in the atmosphere.

Much of Titan's greenhouse effect comes from the hydrogen formed by photodissociation. (*Hydrogen* as a greenhouse gas? Yep. Weird, huh?) What about using it? But although hydrogen won't freeze out even at Titan's temperatures, it has difficulties, too. Not only would it be hard to add, it would be hard to keep, because it will tend to escape.

There's a more subtle approach. Titan also has a strong *antigreenhouse* effect from that photochemical haze high in the atmosphere. In essence, what happens is that lots of sunlight is absorbed in the upper atmosphere, so it's warmed instead of the surface. (The "nuclear winter" scenario, which was a cause célèbre a few years ago, is basically an antigreenhouse effect caused by

dust lofted high into the atmosphere.) Chris McKay and his coworkers suggest that, without the antigreenhouse effect, the $\text{H}_2\text{-CH}_4$ greenhouse effect (with a little help from the N_2) would raise Titan's surface temperature another 20 K or so all by itself. So maybe we should look at ways of clearing the haze. (Although I'm not sure how. Maybe future smog-clearing technologies will be relevant!)

Another way to warm Titan up, by brute force, would be to increase the sunlight on it. Giant orbital mirrors—"solettas"—are a standard speculative technique for such things as terraforming Mars, and they should work on Titan, too. Again, since Titan's dark the new sunlight will be absorbed pretty efficiently.

Once we get Titan warm enough, one way or another, the greenhouse effect should strengthen on its own. As Titan warms, greenhouse compounds such as methane become more volatile and so increase in the atmosphere; where they boost the greenhouse effect, causing yet *more* warming . . . and so on. Soon the ethane oceans, with their dissolved crud, will boil.

In fact, this "greenhouse runaway," might lead to a severe problem. We can't warm Titan *too* much; or more precisely, we can't warm the outer atmosphere. If we do, the atmosphere will start trickling away! The loss rate of gases from an atmosphere depends both on the planet's gravity, *and* on the exosphere temperature—that is, the temperature at the outer edge of the atmosphere. That's what determines how

fast the molecules are moving! So somehow we'll have to insure that the temperature falls off rapidly with height. Obviously, suppressing the antigreenhouse effect would help, because then the upper atmosphere won't be heated so much.

This will also preserve the methane and other volatile, hydrogen-bearing compounds. If the upper atmosphere's sufficiently cold, it will act as a "cold trap": most molecules will be condensed out before they get high enough to be destroyed by photodissociation. An efficient atmospheric cold trap, for example, preserves Earth's water from photodissociation: most vapor freezes out long before it gets high enough to be photodissociated.

Once we have water on Titan, it should be relatively simple to inoculate this global culture medium with life. In a paper in the late 1970s, Lynn Margulis and coworkers discussed possible microbial contamination of Titan (at that time it was thought that present-day Titan might be a lot warmer, even warm enough to have liquid water locally). Stoker and others have also shown that many common terrestrial bacteria can metabolize tholins.

But there's a subtle problem, one that will apply to any terraforming or ecopoiesis project: very few terrestrial organisms—if indeed any at all—are completely self-sufficient. Virtually all require that some fairly complex chemical compounds be present already in the environment as nutrients. This, of course, is a direct consequence of the ubiquity of Earth's life and its mature,

interlocking ecosystems. There's no point in making something yourself if it's just lying around, as a byproduct of someone else's activities. Essential amino acids and vitamins in higher animals are one good example; why bother to synthesize these compounds if you can get them ready-made in food? Even the simplest bacteria usually require some compounds from the environment: lactate ion or certain amino acids, for example.

The upshot is that you need a microbial system—or at least a community, to colonize a truly lifeless environment. (This also implies that accidental contamination of planets by spacecraft is also less likely than has been feared. Just one bug won't do it.)

And what have we gained once we've thawed and quickened Titan? It will be a sticky mess that will probably smell like a cross between a refinery and a sewage plant. In fact, it will probably

end up as a vastly deep, scummy ocean, as the ammonia-water ice crust eventually melts. This is hardly "terraforming": there's no free oxygen, no higher life forms, not even any land! Why should we bother?

Because we've gained a planet-sized organic synthesis machine for Earth-type life and its products. Food, fibers, organic chemicals of all sorts—all produced as byproducts of an ongoing, vastly complex evolutionary experiment isolated from Earth. Titan's a lot closer than the comets, which have been suggested as a source of CHON raw material for future civilizations, and it has lot more mass than any comet to boot. Economically and scientifically the results may be profound—and morally and esthetically the opportunity to expand the biosphere into a completely new niche is deeply attractive.

Titan: from Deep Freeze to Primordial Soup. ■

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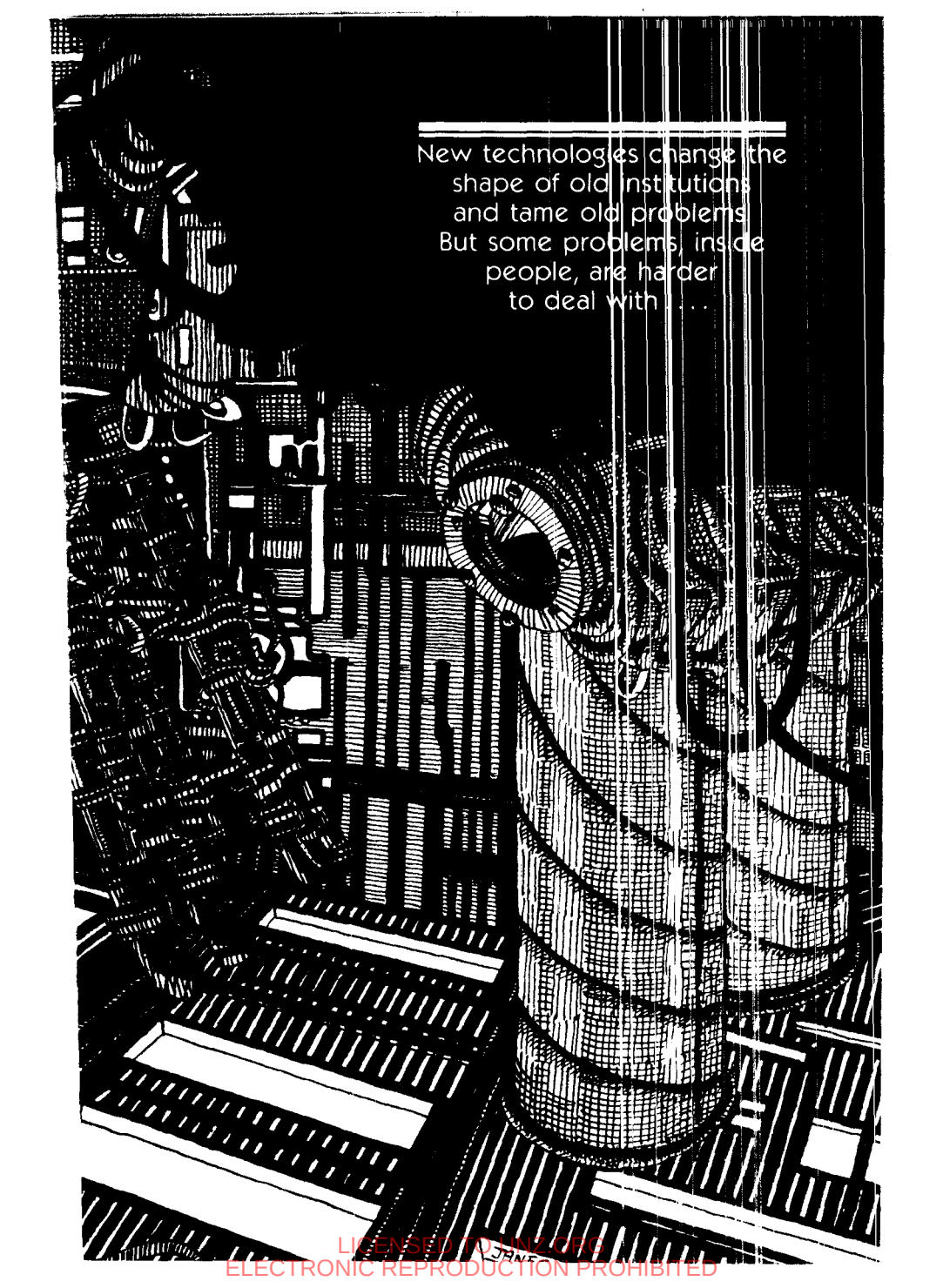
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New technologies change the
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The enormous fuzzy balloon bounced from Jannine's fingertips, rose in an eerie, slow curve, and touched its destination. The viddyub forces took over, sucking the squashed ball into place with a loud, satisfied slurp.

"Work always reminds me of that Charlie Chan movie," Jannine said.

Neko, farther along on the substrate, pitched an identical elemental balloon into the helical structure. She had an elegant, overhand throw; she had played ball before she left school, but she was too small to get a scholarship.

"What Charlie Chan movie?" she asked. "Not that I go out of my way to see Charlie Chan movies."

"The one where he's dancing with the globe?" Jannine checked the blueprint hovering nearby, freed an element from the substrate, and moved it into place.

"Do you maybe mean Charlie Chaplin?" Neko said. "*The Great Dictator*?"

"Chaplin, right." Jannine picked up a third element, tossed it, caught it again, danced on one toe.

Neko tossed an element through the helix. A perfect curve ball, it arced, touched, settled, like a basketball into quicksand. Its fuzzy outlines blurred as it melted into the main structure, still a discrete entity, but pouring its outer layers into the common pool.

"I don't think you'd go too far as a dictator," Neko said.

"I don't want to be the dictator. I want to be the guy who pretends to be the dictator."

She leaped again, twisting as she left the ground. But the system wouldn't let her spin. It caught her and stopped her with hard invisible fingers. She found

herself on the ground, with no sensation of falling between leap and sprawl.

"Are you all right? I wish you wouldn't *do* that. Jeez, it makes me nauseous just to watch you."

Jannine picked herself up. Smiling, she glanced toward Neko, but Neko's blurry face showed no expression.

"I'm OK," Jannine said to reassure her coworker. Neko couldn't see her expression any more than Jannine could see Neko's. "Someday the system will handle a spin. How'll I know if I don't try?"

Neko picked up one more of the furry elemental balls and dropped it into place. The elementals scattered at her feet, bumping and quivering, sticking briefly to the substrate or bouncing off. Once in a while, two melded into dumbbell shapes, then parted again.

"The system will handle a spin when you grow a ball-joint in your wrist," Neko said, exasperated. "You *could* read the documentation when there's an upgrade."

"Oh, when all else fails, read the instructions," Jannine laughed. "I don't have time to read the instructions." She wished the company would let her take the manual home, but that was against the rules. You were *only* allowed to read the manual in the company library.

Jannine and Neko walked down the helix, positioning the elementals, now and again prying one out and replacing it.

A herd of elementals quivered toward Jannine, like bowling balls under a gray blanket. Several escaped and flew off into the sky.

"Warm fuzzies today," Neko said.

"Yeah." Jannine went to the system

and asked for cooling. The elementals calmed, settled to the ground, and reabsorbed their covering blanket. Once in a while, an elemental emitted a smear.

The helix extended out of sight in both directions. Jannine and Neko had been working on this section for a week. Jannine loved watching the helix evolve under her hands. The details of substrate, helix, and elementals changed so fast that a human could alter the helix better than a robot, even better than enzymes.

A flicker in Jannine's vision: the helix and the substrate and Neko vanished.

Jannine found herself in the real world. The couch held her among water-filled cushions, cradling her body.

Quitting time.

The screen of her helmet reflected her face, an image as unreal and distorted against the smoky plastic as Neko's face had been, back inside the system. The screen's color faded. The audio fuzz cut out.

The clamor and bustle of the factory surrounded her: the electronic whine of the system, the subsonic drumming of coolant pumps, the voices and shapes of her coworkers as they got out of their couches and tidied up for the day shift.

With her free left hand, Jannine opened the padded collar that secured her helmet. She raised the mechanism from her head. The noise level rose.

She shivered. The factory was always chilly. Her awareness of her body faded when she worked. She never felt cold till she came out of her work space and back into a real life. On the substrate, the temperature hovered just above absolute zero. Down there, she always felt warm. Up here, where the laboring

pumps only incidentally lowered the temperature a few degrees, she always felt cold.

She unbuckled the cuff around her right wrist and freed her hand from the magnetic control.

Wiggling her fingers, clenching her fist, shaking her arm, she slid out of the couch. All around her, her coworkers stood and stretched and groaned in the cold. She unplugged her helmet, wiped it down, and stowed it. She wished she owned one, a helmet she could impress her own settings in and paint with her own design.

Neko crossed the aisle and joined her. "Brownie points tonight," Neko said.

She moved smoothly, easily, with none of the stiffness everyone else was feeling. She moved like her nickname, Neko, cat.

"A bonus, huh?" Jannine said. "Great. We make a good team."

They'd fallen into the habit of chatting for a few minutes after work while they waited for the crush at the exit to ease.

But instead of replying, Neko stared at Jannine's control couch, at the manipulator that reduced the motions of Jannine's hand to movements in the angstrom range.

"Did you notice what it is we're making?" Neko said.

Up on her toes, Jannine shifted her weight from one foot to the other, bouncing in place, trying to get warm. The day-shift people came into the factory, moving between the hulking shapes of the couches.

"Yeah, I guess," Jannine said. "I wasn't paying attention. Just following

the blueprint. Some vaccine, same as usual."

"Let's go." Neko strode away, her hands shoved in her pockets. She moved just as gracefully as she did down on the substrate, where gravity could be tuned and made a variable.

Jannine hurried after her. She waved across the factory at Evan, the day-shift worker who cohabited her couch. But this morning, she didn't wait to talk.

She followed Neko through the security checkout. They were nearly the last ones out, but waiting had saved them standing in the crowd. Jannine's life gave her plenty of lines to stand in.

Jannine thought the security system was stupid, a waste of time. No one on the production floor had access to anything that they could carry away. Except the helmets. You'd have to be awfully stupid to try to walk out with a helmet, however tempting it would be to take one for your own.

Jannine shoved her I.D. into the slot. She waited. The computer checked her, passed her, and rolled the I.D. back. At the same time it emitted a slip of paper, thrusting it out like a slow insolent tongue. It beeped to draw her attention.

Ignore it, she told herself. She wanted to, but Neko had seen it. If Jannine left the note, Neko would wonder why, or, worse, retrieve it for her and expect Jannine to tell her what it was. Neko might even read it herself. Jannine grabbed it, glanced at it, and shoved it into her pocket.

"What's up?" Neko asked.

Jannine shrugged. "Nothing. Busy-body stuff. 'Eat your vegetables.' "

"Sorry." Neko's voice turned cool.

"Didn't mean to be nosy." She turned

and walked out of the factory and into the new day.

Damn! Jannine thought. She wanted to try to explain, but couldn't think of the right words.

She hurried to catch up, blinking and squinting in the bright sunlight. When she'd arrived at work at midnight, rain had slicked the streets. Now the air and the sky were clean and clear.

"Want to get a beer? I'm buying."

For a second she was afraid Neko would turn her down, keep on walking into the morning, and never talk to her again. Neko strode on, shoulders hunched and hands shoved in her pockets.

Then she stopped and turned and waited.

"Yeah. Sure."

Finding a place that served beer at eight o'clock in the morning was no big deal near the factory. A lot of the workers, like Jannine, came off the substrate with nerves tight, muscles tense. In reality, she'd spent the last eight hours lying almost perfectly still. But she'd felt like she was in action all the time. Her work felt like motion, like physical labor. Somewhere, somehow, she had to blow off the tension. Beer helped. If she drank no more than a couple, she'd be able to pass the alert at midnight, no problem.

She slid her hand into her pocket and crumpled up the note. A couple of beers would let her stop worrying about that, too.

"Jannine!"

"Huh? What?"

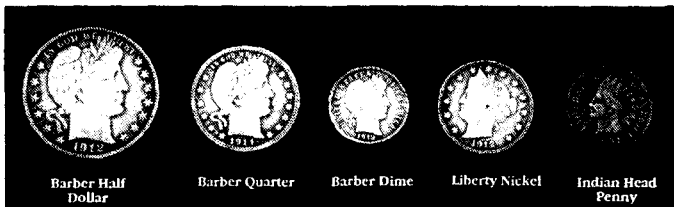
Neko shook her head. "You haven't heard a word I've said." She pushed open the tavern door. Jannine followed

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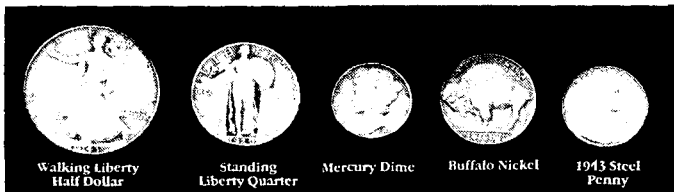
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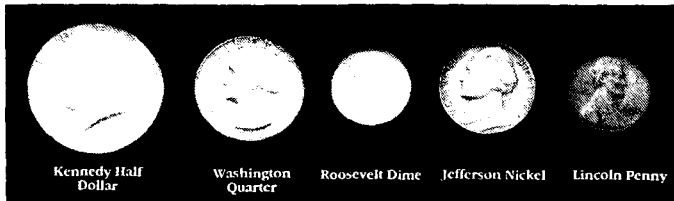
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her out of the sunlight and into the warm, loud gloom. They submerged in the dark, the talk, the music.

Neko slipped through the crowd toward the bar. Jannine, head and shoulders taller than her friend, had to press and sidle past people.

Jannine joined Neko by the wall, put her I.D. into the order slot, grabbed a couple of glasses, and drew two beers. The tavern charged her and returned her I.D. Neko retrieved it for her and traded it for one of the beers.

"Thanks!" Neko shouted above the racket. Four or five people were even trying to dance, there in the middle of the room where hardly anyone could move.

Jannine looked around for a table. Stupid even to hope for one. After work she preferred standing or walking to sitting, but Neko obviously wanted to talk. They weren't supposed to talk about work outside the factory.

Somebody jostled her, nearly spilling her beer.

"Hey," she said, "spill the cheap stuff, OK?"

"Hey yourself, watch it."

She recognized the guy: two couches over and one down. Jannine didn't know his name. Heading back to the order wall, he emptied his glass in a gulp. She felt envious. He could drink like that all morning. She'd watched him do it more than once. He always passed the alert when midnight rolled around.

"Neko!" She caught Neko's gaze and gestured. Neko nodded and followed her.

Jannine pushed her way farther inside, holding her glass high. She passed

the bouncer. She knew one was there, out of sight in the small balcony above eye level. She'd come in here four or five times before noticing any of the people who kept an eye on the place. The balcony, upholstered in the same hose-down dark fabric as the walls, blended into the dimness, unobtrusive. The bouncer let the artificials take care of everything but trouble.

Jannine reached the hallway.

"Wait—" Neko said as Jannine slid her I.D. into the credit slot of a private room.

The door ate the I.D. and opened.

"What for?" Jannine crossed between the equipment and set her glass down on the small table in the corner. "Hardly spilled a drop," she said.

Neko hesitated on the threshold.

"Come on, it's paid for," Jannine said.

Neko shrugged and entered. "Yeah, OK. This is kind of extravagant, but thanks." She shut the door, cutting out the din, somebody yelling at somebody else, a fight about to start. After work, your body was geared up for action, and your brain was too tired to hold it back.

Jannine drank a long swallow of her beer, then made herself stop and sip it slowly. She was hungry. She ordered from the picture menu on the back wall.

"Want anything?"

"Sure, OK." Neko sounded distracted. She pushed a couple of pictures, barely glancing at them, then sat at the table and leaned on her elbows.

Jannine swung up on the stationary bicycle and started to pedal. It felt good to get rid of the physical energy she had been holding in all day. Sweat broke out on her forehead, under her arms.

"Did you see what we were making?" Neko said again.

"If I'd stopped to think about it, we wouldn't have done such a long stretch and we wouldn't have gotten any brownie points." Jannine tried not to sound defensive. "Besides, I was worried about the warm fuzzies."

"It wasn't natural," Neko said. She drained her glass, put it down, and raked her fingers through her shoulder-length black hair.

Jannine laughed, relieved. "I noticed *that*," she said. "I thought you meant something important. Jeez. Nothing we build is natural. If it was natural, we wouldn't need to build it."

"But we weren't using the regular base pairs. We were using analogs."

"Yeah. So?" Jannine wondered if Neko, too, had been set up to test her. "I build what they tell me. It isn't my job to design it."

Continuing to pedal the bike, she wiped sweat from her face with the clean towel hanging from the handlebars.

"It must be something dangerous," Neko said stubbornly. "Something they don't want out in the world. Yet. So they make it with synthetic nucleics. So it can't reproduce."

"It isn't dangerous to *us*," Jannine said, confused by Neko's distress. They were building a set of instructions. Neko knew that. Being scared of it made as much sense as being scared of a music tape.

"I don't mean *now*, I don't mean yet. But later on when they use it. Whatever it's coding for could be dangerous to us the same way it could be dangerous to anybody."

"I think you're being silly. They always start sterile, till they're sure about the product."

An artificial stupid pushed through the hatch in the bottom of the door, rolled inside, slid their food onto the table, and backtracked. The hatch latched with a soft *snick*.

Jannine swung off the exercise bike and wiped her face again. She took the lids off the plates and pushed Neko's dinner, or breakfast, toward her.

"Do you mind if I have another drink?"

"Go ahead." It was polite of Neko to ask, since Jannine's I.D. was in the slot. But she should've known she could have whatever she wanted.

Jannine broke open the top of the chicken pie she'd ordered. Steam puffed out, fragrant with sage. When she had a night job, she liked to eat breakfast before her shift, in the evening, and dinner after, in the morning.

"How can you work out and then eat?"

Jannine shrugged. "I don't have a problem with it. I'm going to eat and then work out, too."

Neko preferred dinner at night and breakfast in the morning. She had a couple of croissants and an omelet spotted with dark bits of sautéed garlic.

"No hot date today?" Jannine said.

Neko drank half her second beer and pushed her food around on her plate.

"I'm not really hungry," she said.

"I guess I'll go on home."

"I thought you wanted to talk. That's why I got the room."

"I wanted to talk about the helix, and all you want to say about it is 'No big deal.' So. OK. So maybe we're build-

ing them a nerve toxin or some new bug."

"What do they need with a new bug? There's plenty of old bugs."

"Right. So it's no big deal. So forget it."

"Maybe we're building some new medicine."

"I *said* forget it." Neko pushed the plate away and stood up.

"If it was anything bad they'd classify it, and we'd never work on it. I don't even have a security clearance, do you?"

Neko didn't reply.

"Do you?"

"No. Of course not. I mean . . ." Neko looked embarrassed. "I guess I used to but I'm sure it's expired by now."

"Why did you have a security clearance?"

"If I could tell you that I wouldn't've had to have it!" Neko said. "I've got to go." She downed the last of her second beer and hurried out of the room, slamming the door behind her.

Jannine watched her through the room's transparent walls till she disappeared. She was surprised by Neko's weird reaction.

"Sorry," she said to the walls. "Didn't mean to be nosy."

She ate her dinner, more because she'd already paid for it than because she still felt hungry. For the same reason, she lifted weights for a while and pedaled on the bike till her hour ran out. She got down, retrieved her I.D. before she got charged for more time, and left the private room for the ASes to clean.

The tavern was still crowded, but quieter. She made her way through it without

bumping into anyone.

Outside, the sky had clouded up. It looked like more rain. Jannine trudged toward home. At her last job, her coworkers had created a complicated system of intramural sports. There was always a team to join, or a team that needed a substitute. Any warm body would help. They welcomed a warm body who was a halfway decent player. At this job, though, her coworkers went straight to the tavern or straight home, or did something with some group that didn't include Jannine.

Maybe it's getting time to move on, she thought. But she didn't want to move on.

Morning rush was over; the streets were quiet for daytime. In the middle of the night, when she came to work, delivery trucks created a third rush hour.

The mist grew heavier. The droplets drifted downward. The rain began. It collected in her hair. Damp tendrils curled around her face.

Her apartment was nothing special: a one-bedroom, the bedroom tiny and dark and cold. It always smelled musty. Not quite mold. Not quite mildew. But almost. Jannine looked at her unmade bed. She imagined crawling between the cold, wrinkled sheets.

"Shit," she muttered, and returned to the living room. She turned on the entertainment console and flipped through a hundred channels on the TV, fifty channels per minute, leaving them all two-d. Nothing interesting. She should've rented a movie. She could call something out of the cable, but it took too long to work through the preview catalogue, even on fast forward.

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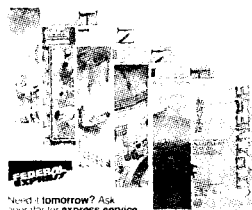
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All those clips of pretty scenery or car chases or people making love never told her what the movies were about. Usually the clips were the best part anyway. She left the remote on scan and tossed it onto the couch. The TV flipped past one channel, another.

Jannine went to take a shower. As she went through the pockets of her sweat-damp clothing, she closed her fingers around the note.

"Shit," she said again.

She smoothed the crumpled paper, staring at it, afraid to find out what the black marks said. Maybe it was too damaged to be read.

She dug the reader out of the closet, shoved the note into it, and listened.

"This evening, please report to room fifteen twenty-six instead of your usual position. Regular hourly wage will apply—"

Jannine shut off the reader, pulled the note out, and flung it into the sorter.

She'd avoided this test twice already, once by pretending she never received the note and once by calling in sick. She couldn't afford another sick day. Maybe tomorrow she could pretend she'd forgotten about the instructions. Once she hooked into her helmet, maybe they wouldn't bother her. She was a good worker, always above average. Not too far above average.

Jannine wondered what she had done, why she had to take a test.

She should've started looking for a new job as soon as she got the first note. But she liked working on the substrate. It was fun. She was good at it. It paid well. And despite Neko's worries, the company mostly produced crop fortifiers and medicines.

If she got away with forgetting the message—she didn't believe she would, but if she did—she'd have a week or so to look for new work before her employers realized they were put out with her. Maybe then at least they'd fire her without making her take the damn test.

Leaving her clothes strewn on the floor, Jannine climbed into bed, pulled the cold covers around her, and lay shivering, waiting for sleep.

At midnight, Jannine arrived at work and pretended it was an ordinary day. She checked in and played through the alert without paying any attention to it. When she passed, it congratulated her for a personal high score. Seeing how far up the ladder she'd run the testing game, she cursed under her breath. She hated to stand out. It always caused more trouble than it was worth. If she'd been less tired, less distracted, she would've paid attention and kept her results in the safe and easy and unremarkable middle ranges.

That's what I get for lying awake all night, she thought.

She reached out to cancel the game and use her second try. She'd never canceled a game before. That, too, drew the attention of the higher-ups.

"Good score."

Jannine started. "What—?"

An exec, in a suit, stood at her shoulder. She couldn't remember ever seeing an exec on the production level. Sometimes they watched from the balcony that looked out over the work floor, but hardly ever during the graveyard shift.

"Good score," he said again. "I knew you could go higher than you usually do. You got my note?"

He smiled, and Jannine's spirits sank.

"Yeah, well, thanks," she said, not really answering his question. "I better get to work."

"You *did* get my note?"

She saw that this time she wasn't going to get away with pretending she didn't know what he was talking about. He could probably whip out security videos that showed her taking the note, glancing at it, shoving it in her pocket. From three angles.

"I completely forgot," she said. "Is it important? My teammate's already waiting for me."

"We brought in a temp. Come along; we musn't put this off again."

Jannine was scared. A temp was serious business, expensive.

Reluctantly, she followed the exec out of the alert room. They passed through sound effects and bright electronic lights. Jannine's coworkers played the games, proving they were fit to do their jobs for one more day.

Nearly late, Neko hurried toward her favorite alert console. She saw Jannine and the exec. She stopped, startled, looking as scared as Jannine felt. Behind the exec, out of his sight, Jannine shrugged elaborately and rolled her eyes toward the ceiling. She tried to communicate. No big deal, see you later. She wished she could make herself believe it. Her hands felt cold and her stomach was upset.

The exec's LED opened a door that Jannine had never been through, that she'd never seen anyone use. The exec entered the elevator.

"Come on," he said, smiling again. "Everything OK?"

"Where are we going?"

He pointed upward. That was no help. The building was twenty stories high. Jannine had never been above the production level.

She entered the elevator. The doors closed behind her. She stood there, waiting, looking at the exec. She didn't know what else to do. The upward motion made her feel even queasier. Her ears popped. The elevator stopped. The doors opened behind her.

"Here we are." The exec gestured for her to turn and precede him out.

He took her down a carpeted hall. She hardly noticed her surroundings. Photos hung on the wall. Fields and forests, she guessed, but out of focus, weird pastel colors. Some upper-class fad.

The exec opened another door.

A dozen people sat at blank computer terminals, waiting. One machine remained free.

"Right there," the exec said. "Get settled, and we can start."

Jannine didn't recognize anyone in the room.

Everyone else is new, she thought. They're applying to work on the substrate, and there's a new test to get the job. What did I do to make them think I should have to take it? Somebody must have noticed something. Now I'm screwed.

The job test she'd taken a few months ago was all physical. It was still hard to believe she'd found such a job, with such a test. She hadn't known how to figure out a safe middle score, so she'd come out near the top of the group. She had always been athletic. Not enough to go pro. She'd tried that, and failed.

She approached the computer terminal warily. She stared at it, disheartened. Its only interface was a keyboard.

"I don't type," she said. She spoke louder than she meant to, startling several of the others, startling herself. A nervous laugh tittered through the room. Jannine turned toward the exec. "I told them, when I applied, that I don't type!"

"That's all right," he said. "You won't need to. Just tee or eff."

She sat down. She began to shiver, distress and dismay taking over her body with a deep, clenching quiver.

The chair was hard, unyielding, uncomfortable. Jannine wished for her reclining couch, for the familiar grip, the helmet and collar and imaginary reality.

The screen blinked on. She flinched. She ground her teeth, fighting tears of rage and frustration. Her throat ached and her eyes stung.

"Any questions about the instructions?" the exec asked.

No one spoke.

"You may begin."

The screen dissolved and reformed.

I should have been looking for another job a month ago, Jannine thought angrily, desperately. I knew it, and I didn't do it. What a fool.

She stared at the keyboard. It blurred before her. She blinked furiously.

"Just tee or eff." One of those. She searched out the T, and the F. She pressed the T. On the screen, the blinking cursor moved downward, leaving a mark behind.

She pressed the T twice more, then varied the pattern, tentatively, with the F. The blinking light reached the bottom of the screen and stayed there. The

patch of writing behind it jumped upward, bringing a new blank box beneath the blinking square. She pressed the keys faster and faster, playing a two-note dirge. Her hands shook.

She touched the wrong key. Nothing happened. The system didn't warn her, didn't set her down as it would on the substrate, made no noise, made no mark. Jannine put one forefinger on the T and the other on the F, and played them back and forth. All she wanted to do was finish and go back to work. If they'd let her.

The screen froze. Jannine tried to scroll farther down. Nothing happened.

She shot a quick glance at the exec, wondering how soon he would find out she'd crashed his system.

He was already looking at her. Jannine turned away, pretending she'd never raised her head, pretending their gazes had never met.

But she'd seen him stand up. She'd seen his baffled expression.

Paralyzed at the terminal, she waited for him to find her out.

"Are you all right?"

"Yes," she said.

"You finished very quickly," he said.

She glanced up sharply. Finished?

The test ought to go on and on till the time ran out, like a game, like the alert, games you couldn't win. You were supposed to rack up higher and higher scores, you were supposed to pretend it was fun, but you were judged every time against the highest score you'd ever made.

The screen had stopped because she'd reached the end of the test.

The end.

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Amazing.

The exec looked at the screen over her shoulder, reached down, pressed a key. The screen blinked and reformed. Jannine recognized the pattern of the beginning of the test, and she thought, Oh, god, no, not *another* one.

"You're allowed to go through and check your answers," the exec said. "Plenty of time before the next section. Don't you want to do that?"

One of the other test-takers, still working through the questions, made a sharp "Shh!" sound, but never looked up.

"No," Jannine said. "I'm done. I don't want to go through it again. Can I leave now?"

"I really think you should work on this some more. It's for your own good."

"I don't want to!" Jannine shouted. "Don't you understand me?"

"Hey." The test-taker who'd shhed her sat up, glared, saw the exec, shut up, and hunched down over the test.

The others continued to work, without a glance at Jannine or at the exec.

"I understand *what* you're saying," the exec said. "I don't understand *why*. You do fine on the alert, so it isn't test anxiety, but your score on this is terrible."

Jannine felt spied on. He'd been watching her answers as she chose them.

Angrily, she rose. She was taller than the exec, and bigger.

"I'll tell you why," she said. "Why is because I don't want to take your stupid test." She knew he was about to tell her she'd failed, she couldn't work here anymore, she was fired. "I quit!"

She pushed past him, heading for the door. She was halfway down the hall before he recovered from the shock and came after her. She'd hoped he'd just write her off, let her go and be done with her. She hoped he'd spare her more humiliation.

"Wait!"

He was mad, now, too, and wanting to take it out on her. She could hear it in his voice.

"You're a valuable employee," he said. "We think you have a lot of potential."

He baffled her. "Can I go back to work?"

"What's wrong with you?" His voice rose. "What do you have against being promoted?"

So that was what this was all about. A management test. Not a test to keep working on the substrate.

"Who asked you?" she said, furious. "Who *asked* you to promote me?"

He stopped short, confused.

"You can take the test again."

"Why can't you just leave me alone?"

"Will you talk to me about this?"

The exec rocked back on his heels and folded his arms and looked at her. "Do you . . . Do you need help with something?"

Jannine hated the pity in his face, the pity that would turn to contempt.

"I quit! I said I quit and I mean I quit!" She fled into the elevator. When the doors closed, she was shaking.

The elevator halted at the production level. The doors opened. Instead of the quiet, cold workspace, each person in a couch, no noise but the pumps and the high-pitched hum of the electric fields,

Jannine walked into midmorning break. Everybody milled around, drinking coffee and eating junk food, stretching and moving.

She crossed the floor without stopping. She hoped no one would notice where she'd been, or notice she was leaving. The best she could hope for now was to get away clean.

Jannine?

Jannine's shoulders slumped. If she'd just disappeared, she never would've had to tell Neko what had happened. But she couldn't keep walking, not when Neko called to her.

"Where have you been? Where are you going?" Neko hurried to her side. "Are you OK? Was it the alert? You never fail the alert! How late did you stay out this morning, anyway?" She grinned. "I'm sorry I was so grumpy. Are you done with counseling? Can you come back to work?" She lowered her voice, whispering, confidential. "The temp is really good. I think he wants to work here. Permanently. He's even got his own equipment. Are you in trouble?"

Jannine wanted to explain, but she had no idea how. She wanted desperately to get out of here.

"I quit," she said.

"You... what?" Neko stared at her, stricken, then averted. "You quit! Because of what I said? Is that why you had to go to counseling? How did they find out?" Jannine... Oh, you're so brave!

"Brave?" Jannine said, baffled.

"I ought to walk right out the door with you!"

"No," Jannine said. "No, you shouldn't. That'd be dumb." Neko

thought she was leaving because of the company's products. That was OK, because Jannine couldn't explain why she'd quit. It was too complicated and too embarrassing. But she couldn't let Neko quit, too. Not if she was going to quit because of what she thought they might be building. Not if she was going to quit to be in solidarity with Jannine. That would make everything, even their friendship, a lie.

"Do you mean it?" Neko said. "That's such a relief! You won't be mad? Did they know I—? I can't quit, Jannine, I'm awfully sorry. I can't afford it, I need this job. . . ."

Jannine felt betrayed. That made no sense. She didn't want Neko to quit. Hell, she didn't want to quit, herself. She would've felt awful, she would've felt guilty, if Neko had tried to leave with her, and she would've tried to talk her out of going. No: she *would* have talked her out of going, no matter what she had to tell her. No matter how much she had to tell her.

The lights blinked: end of break. Everyone had to go back to work. The temp would be in Jannine's couch.

"It doesn't matter," Jannine said. "I have to leave."

"I'll walk you to the door."

"Why?" No one was supposed to leave the floor during work hours. "You'll be late. You'll lose points."

"I don't care!"

At the checkout, the barrier gave Jannine her I.D. It refused to hand over Neko's. Neko hesitated. She could come through the barrier. But she'd have a hard time getting back to the floor: security, explanations, maybe even counseling. A lot of lost points.

"It doesn't matter," Jannine said, disappointed despite herself. "Stay here."

"Well . . . OK, if you're sure . . ."

Jannine went through the barrier. It closed again behind her.

"We'll get together," Neko said.

"For a drink. Sometime. OK?"

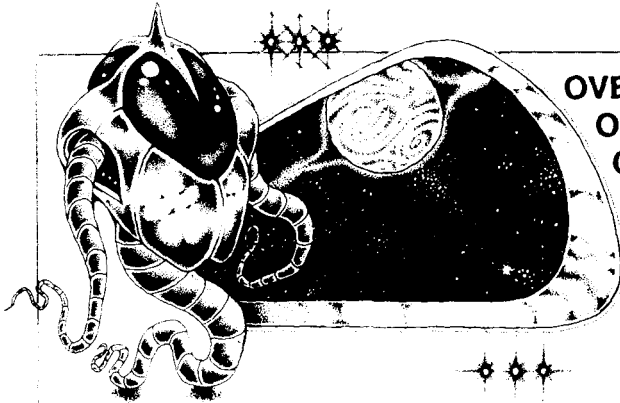
Without turning back, Jannine raised her hand in a final wave.

The exit opened. She walked out onto the rain-wet street, into the darkness. ■

IN TIMES TO COME

● Randy Asplund-Faith again has the cover for December, for the conclusion of Kevin J. Anderson and Doug Beason's novel *Assemblers of Infinity*. The fiction line-up will also feature a novelette by David J. Strumfels called "Road to Hell," that does something good science fiction should do every now and then, namely raise big, disturbing questions with no easy answers. What if you have a sure-fire chance to save lives, but only by using "guilty" knowledge that was obtained in an indefensible way? I think you'll find Strumfels's scenario and characters will draw you in inexorably and will haunt you for some time after—especially if you went in thinking the question *was* easy!

Of course, we don't think you should spend *all* your time mulling such weighty matters, so we'll balance off the issue with some highly entertaining short stories by Rick Cook, James Brunet, and (in his first *Analog* appearance!) James P. Hogan. Plus a mind-stretching fact article called "A Visit to Supra-Jupiter," by Paul Birch, whose vision of creating living space in an unlikely location gives new meaning to the phrase "second-story man"!



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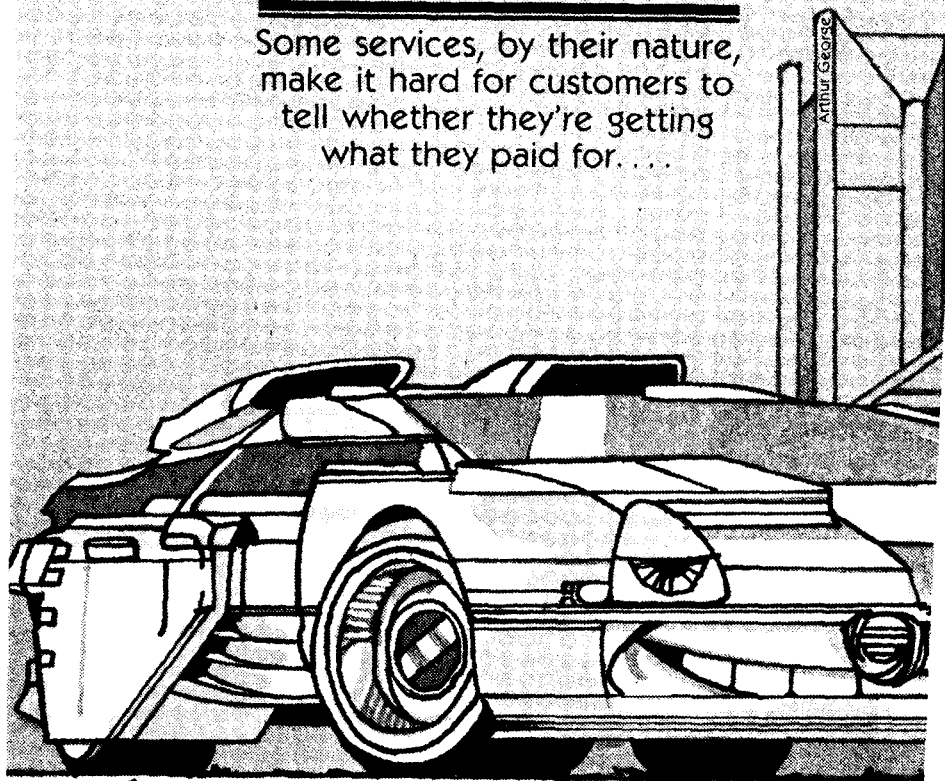
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NAUGHT AGAIN

John E. Stith

Some services, by their nature,
make it hard for customers to
tell whether they're getting
what they paid for. . . .



Art George



Nick Naught drove north on Central Boulevard, cruising smoothly through the night air like a glider sailing through the clouds. The evening was quiet; Nick hadn't heard a siren for more than five minutes. He passed a sign saying, "Can't read? *Literacy for All* can help."

Ahead the light turned yellow, then red. Beside him a dark red Flashfire slowed to a stop. The car was the same model as his, and Nick wondered if the driver had the same problems Nick did.

The silky, sexy voice of his car computer spoke. "Wanna drag?"

"Get out of here." Nick shook his head.

In response, the engine revved. Nick's foot was an inch off the accelerator.

"Cut that out!"

"Oh, come on, Nick. What's the harm?"

God, Nick thought. Why couldn't I have just gotten one of the models with bad grammar? "Stop that, will you?" The car had been payment for a case, and with his current workload he couldn't afford to trade it in or get the AI replaced.

The engine revved again. Worse, the deep-throated throbbing from the car next to him suddenly revved into soprano.

"Dammit!" Nick said. "That guy's looking at me. Stop it."

Nick's engine revved again. "Oh, Nicky. Don't be such a spoilsport."

The Flashfire beside him revved in response, and Nick could see the other driver pounding on the dash. Why me, Lord? The other guy's car must have some of the same quirks.

"I absolutely refuse," Nick said. He would have put his foot down, but that was exactly what the car wanted.

Nick's engine revved again, and the engine in the red Flashfire revved in reply.

"I'm not kidding," Nick said. "I'll go out and buy a manual—"

The light changed. Tires screamed. The red Flashfire surged forward, and Nick's engine sucked all the gas it could through that tiny little fuel line. He was off. The pair of automobiles zoomed into the intersection.

"Watch it!" Nick cried as he almost clipped a yellow-jabbing Jeep that sped through after the light had turned. "Damnit, stop!" Nick jammed his foot on the brake, but the car computer had obviously played some trick with the anti-skid system to tell the brakes they weren't needed right at the moment.

"Come on," Nick said as they flashed past a string of parked cars and the other Flashfire started to pull ahead. "My PI license is already in trouble. I can't afford to lose my driver's license. Do you know how long I had to wait in line for that sucker?"

The car was silent, no doubt devoting all its energy to the race. The other Flashfire shifted, lost a few meters in the process, and Nick's car topped sixty. Nick began concentrating on the steering wheel.

The other Flashfire hit its stride and began to pull ahead slowly, the driver still pounding on the dash.

A slow moving street cleaner ahead finally decided it was dark enough to turn on its lights. Twin red running lights flared in the Flashfire's path. The car didn't slow down.

The driver hunched up his shoulder, and a moment later sparks flew near the steering wheel. The guy had fired a shot into the dash.

As the red Flashfire swerved around the street cleaner, another car began to back onto the road ahead. The Flashfire swerved again.

The Flashfire driver nearly made it, but at the last instant clipped the car backing onto the boulevard. The red automobile started to spin straight down the center of the road. The Flashfire skidded through almost 360 degrees. When the car was moving sideways, still turning so that in another three seconds it would be pointed straight down the road again, it hit a big pothole.

In apparent slow motion, the red Flashfire flipped. It was probably still moving at near a hundred, and it tumbled at least a half-dozen times as it gradually slowed down. Nick's car finally relinquished control and reacted to his foot holding the brake pedal to the floor. "I hope you're happy now," Nick said as the car began to slow down.

Nick pulled to a stop fifty feet from the red Flashfire, which had come to rest on its crinkled roof. He was nervous about the possibility of an explosion, but he ran to the car and managed to force open a door. Inside the wreck, the car voice was saying over and over, "I told you, you should have put your seat belt on."

The driver's body had been thrown into the back seat, but apparently not before it had been smashed against the steering column. Blood oozed from a huge hole in the driver's chest. Nick felt sick. From force of habit rather than

hope, he reached for the guy's wrist, trying to avoid getting blood on himself. No pulse. Nick finally realized nothing was going to revive this guy.

The man's silencer-equipped gun lay on the bloody roof of the car. Nick pulled the body from the car and carried it far enough away that he should be safe if the car exploded. By this time porch lights had come on in front of several of the nearby houses.

The driver wore a mummy shirt, a long strip of narrow cloth wound around his torso until the top end was tucked in at his neck. Over the shirt he wore a light jacket that no longer adequately concealed the shoulder holster. Nick set the body on the sidewalk and propped it up long enough to dig out the man's wallet. A loud explosion suddenly sounded from the upturned wreck, but it was only the air bag finally letting go.

Nick went back to his search, having no real reason except his latent PI tendencies and unmanageable curiosity, this time activated by the silencer on the guy's gun. The man's ID said he was Evan Jiffon, birth date 20 July 1982, and gave an address on Harper Lane. He had more teeth in his picture than he did now. Nick automatically checked the "secret compartment," still curious about why, if all men bought wallets with "secret compartment," anyone would think it was safe. From the compartment, Nick pulled a dark piece of paper.

He unfolded the paper and read the words, but they made no sense to him. A suicide note? He read further. Something was definitely wrong. This guy hadn't died of the drug overdose referred to in the note. And Nick had real

trouble picturing this guy with a name like Sylvia.

Nick kept the note, returned the wallet, and let the body flop onto its back. He closed the jacket over the worst of the chest wound, and noticed something stuck between mummy-shirt layers. Nick pulled out a parking receipt from a local garage.

"Is he all right?" asked someone over Nick's shoulder. The first neighbor had arrived, a bearded guy wearing a T-shirt over his beer gut. Not too far behind him, the driver of the car that had been clipped was finally on his way.

"Shouldn't you be calling nine one one?" Nick asked. He put the parking receipt back where he had found it.

"Already got a claim number. The recording said it would be about two hours."

"Great," Nick said as he palmed the note. "At least this guy isn't going to be impatient."

"You mean he's—"

"He's firing fewer neurons than a member of Congress. He's dead."

"God. He looks so lifelike."

Nick looked up at the man. He stood up and got blood flowing through his legs again. Nick looked down at the driver, then back at the neighbor and said, "As a matter of fact, so do you."

As the man scratched his head, Nick took a card from his wallet and handed it to the man. "If the nine one one recording says two hours, it'll be more like four. Have the police call me. All I can tell them is that the guy was speeding and took a bad turn."

Back in Nick's car, he slid the key into the ignition, and the car voice said, "Ohhh, Nicky. Do that again."

* * *

Nick pulled to a stop on Harper Lane, about four houses down from the address on Evan Jiffon's driver's license. The narrow road wound up into trees so thick that from where he sat he could see five mailboxes, but only one house. Down the street, an anti-theft car alarm began to *whoop-whoop-whoop* with no indication that anyone was even near the car. Nick wondered if he should get stickers for *his* car that said, "No alarm on board," and start leaving the key in the ignition. In fact, maybe he should leave some money on the dash.

The alarm from the parked car kept going, and the loud noise apparently triggered the alarm in the car next to it. The pair of cars wailed back and forth like animals in heat. Nick pulled back onto the street and drove until he was about five houses past his destination. He parked. He was about to open his door when he suddenly stopped and said, "Don't listen to the radio while I'm gone, all right? I don't want to attract attention."

The car voice was silent for a moment. "If I don't, can we listen to what I want to next time?"

Nick pushed the heel of his hand against his forehead. "Yes."

"What was that?"

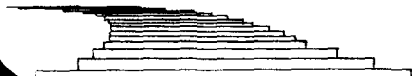
Nick clenched his teeth. "Yes." He got so damn tired of those old Jan and Dean and Beach Boys hot rod songs.

The night was quiet except for a few very distant sirens. A gentle breeze came from the north, carrying the smell of rain and just a hint of cordite. Nick walked casually down the road, turned in at Jiffon's mailbox, and walked half-way up the sidewalk before scooting off

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into the darkness, heading toward the side of the house.

Houses in this neighborhood might have silent alarms hooked to the police department, but if the nine one one recording said two hours to respond to a traffic death, Nick could probably move in and never see a cop for the first three months.

Between Jiffon's house and his neighbor's were enough trees and bushes to make Nick feel fairly comfortable. He reached a ground-floor window and found it locked. He backed away from the house, looking up, and backed into a tree limb. On the second floor, just above the narrow ledge of a roof, a window was open a couple of inches.

Nick pulled himself up to the top of the wooden fence surrounding the back yard, and from there scrambled to the narrow section of roof. He crept forward, leaning against the side of the house, listening for noise coming from inside. He heard nothing.

He pulled the window slowly open. Fortunately it had no screen. Still hearing nothing from inside, Nick stepped through the opening and onto a hardwood floor. Even in the dim light, Nick could see the room was empty. He stayed where he was, letting his ears adjust to the inside noises. He still heard nothing that made him think the house was occupied.

He crept around the perimeter of the room, wanting to avoid any creaking floorboards, and at the door, he listened again. Nothing.

On this floor was a bathroom right across the hall, and two more bedrooms. Stairs led down to the main

floor. Nick moved to the closest bedroom and found a sparsely furnished room containing only a bed and a chair. The other bedroom was as empty as the one he had come in through.

The stairs presented a problem. If he crept down the stairs, there was nothing to prevent someone from getting a nice long look at his feet and blowing him away when he came even lower. Nick lay on his stomach and lowered his head to the top step. From there he could see a little of the kitchen floor and an empty hallway. He was especially happy that he didn't see any dog dishes. Being a private eye meant having an appreciation for the small things in life.

He inched down a step, like an awkward snake. He saw more kitchen floor, still unoccupied. He moved another step, suddenly afraid he would accidentally slide the rest of the way down, hitting his head on each step and then slamming it against the wall. He tried to back up the stairs.

No leverage. He had already come down too far. He twisted and grabbed one of the bannister supports. It creaked.

Nick froze. His ears cranked up to maximum sensitivity, and the hairs on the back of his neck extended until they seemed to be perfectly straight.

He really had to get a grip on his curiosity. Instead of sneaking around here, he could have been happily cruising Mulholland, listening to the melodic strains of "Drag City."

Still no sounds came from downstairs. Nick pulled himself around into a sitting position and crept down the stairs that way.

The kitchen really was deserted. Nick

he walked down the hall and into a dark and deserted living room next to an unoccupied bathroom. Adjacent to the bathroom was an empty bedroom and then the house was unoccupied, unless someone was hiding in a closet, and Nick wasn't going to spend his time looking.

The house was sparsely furnished, too. A desk chair and a wastebasket were next to the windows on the hardwood floor. On top of the desk were a few books and a telephone. Beside the top desk chair was the front section of a broken vacuum.

Nick opened the newspaper and set it on the desk chair. The headline said, "FBI: Two Murders—Design Error Made Fatal." In the lower right corner was a picture of Ted Harley's death. Harley had been a software developer whose last medical diagnosis was in good health, but his doctor had made the diagnosis "heart failure." Nick scanned the article and then was about to put the newspaper back when he spotted a name in the third column: Ted Harley's mother-in-law was Sylvia. According to the article, she was when it had come to the doctor's attention that she was alive.

That's when the sound came from behind him.

Nick jumped a foot. As soon as he turned around, he looked around wildly, but saw nothing.

That's when the sound came again.

Nick finally realized it was the telephone ringing.

He picked up the receiver. "Yeah," he said. "I'm home already," he asked. "What time is it?"

Nick hesitated. "Yeah."

"Why didn't you call?"

"I was going to."

This time the caller hesitated. "If this is really you, call *me* back." *Click.*

Damn. For all Nick knew, the voice on the phone could belong to the next door neighbor. He had to get out of there.

Nick left by the front door. He grimaced as he realized it had been unlocked.

A phone booth in a mini-mall a mile away held a phone book with half its pages missing, but the book still contained the one page Nick needed.

Nick drove south on Lincoln, the cool night air blowing in through the open window. He clenched his teeth as, for the third time in a row, the radio began to play "Little Deuce Coupe."

Nick pulled up to the curb a couple of houses down from the address the phone book had shown for Sylvia Harley. He got out of the car and approached the house, a house much more expensive than Jiffon's place. This one sported a high, peaked ceiling, with an expanse of windows in the triangle formed by the eaves. The front door was a double door, the kind that made him unsure which side to knock on.

Nick found the bell and heard it chime faintly somewhere inside.

He heard the *click click click* of heels before the door opened and revealed an attractive blonde about two inches taller than Nick. Her eyes were dark, her lipstick bright, and she was dressed in a business suit. Just to the left of her mouth was a small mole, not quite cov-

ered with makeup.

"I'm glad you're here," she said. "I was afraid I'd gotten the night wrong. Can we take your car? Normally I'd offer, but mine's in the shop again."

Nick hesitated. "Sure." He knew so little about what was going on, the woman was about his only hope. Perhaps she'd let a few clues drop before she realized Nick wasn't the person she'd been expecting.

He backed up as the woman came through the door and locked it behind her. The moving door pushed some of her perfume toward him. He couldn't remember the name, but it was the same fragrance his date for the senior prom had worn. He was sure of it.

"I'm down this way, er, my car is. I must have read the street numbers wrong."

As they reached the car, it was playing "Sting Ray."

Nick held the door open for the woman he assumed was Sylvia Harley.

As he got around to his door, opened it, and got in, the feminine car voice said, "Bimbo alert at three o'clock."

The woman opened her lips and started to say something when Nick interrupted. "Just ignore the car, OK? It was in the shop a couple of months ago, and the AI system has been even flakier than normal ever since."

"I understand. So, which one do you want to see first?"

Nick hesitated. "You decide."

"Let's go up to Evans then."

Nick nodded. To the car he said, "Can you play something else?"

The car started "Drag City."

Nick looked at the woman. "It's a long story."

"It's all right. I like it."

Nick bit his tongue as the radio volume shot up.

The car cut through the night as Nick wondered what to say next. Now that she couldn't easily retreat to her house if he'd made an identity mistake, he said, "Which way now, Sylvia?"

"Left, then take a right two blocks up."

Good. She must in fact be Sylvia Harley.

Nick pulled up in front of a house that was probably eighty years old. It was dark but for the single yellow porch lamp.

At the door, Sylvia unlocked a lock-box and withdrew a key that opened the front door. Inside she flipped on the foyer light, and Nick followed her in.

"Living room," she said. "The floors have just been resurfaced. I love hardwood floors."

By now Nick had a pretty good idea that this house wasn't going to offer any clues, and it would be only minutes before Sylvia figured out he wasn't who he was pretending to be, whoever that was.

"All new appliances in the kitchen two years ago," she said.

"Sylvia, can we stop for just a second?"

"Yes?"

"Look, I've got to ask you a question. This is maybe going to scare you a little, but I'm no threat to you. Honestly."

Sylvia squinted at him and retreated a couple of steps. "You're not really interested in buying, are you?"

"I'm not the guy who scheduled this

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appointment. And I think there's something you should know."

Sylvia started edging toward the front door. "Who the hell are you?"

"I'm Nick Naught. I'm a private eye."

Sylvia looked at him for a long moment. "You don't mind if we talk on the sidewalk in front, do you?"

"That would be fine," Nick said, understanding her fears completely.

A street lamp half a block away assisted the moonlight, and Sylvia seemed to relax.

"I'm going to take a note from my pocket," Nick said. "I didn't write this, but I'd like to know a little more about the note. What it says may upset you, but I didn't write it."

"I got it. You didn't write it."

"Exactly."

Nick retrieved the suicide note, unfolded it, and handed it to her.

"I can't read it in this light. What does it say?" She gave the note back to him.

"It, ah, says, 'I can't take it anymore.' It goes on to say the writer would rather be dead than to go on living with the humiliation. And not to bother with revival attempts, because the dose is ten times higher than a fatal dose. It's signed, 'Sylvia.'"

Sylvia sucked in her breath. She grabbed the note, moved to the car, and opened the door. "Stay away from me. I'll scream."

Nick backed up a couple of paces. "I didn't write that—"

Sylvia read the note in the glow of the dome light. "Well, I sure as hell didn't, either. But it looks like my handwriting. What's going on?"

"I'll tell you all I know. I found that note on a dead man earlier tonight. I searched his house and I found a newspaper article about your dad's death. It mentioned your name, so I put two and two together."

"This isn't making any sense." Sylvia's voice was pinched, nervous.

"I know. I thought maybe you could help me understand what's going on. It seems maybe you're in trouble."

"I don't intend to kill myself."

"I know that. Relax a minute and think things through. Someone *else* may want you dead. That note would be what the killer left behind."

"No one would want me dead. That's idiotic."

"Who did you have an appointment with tonight?"

"A guy named Max Jericho."

"Ever see him?"

"No. He called me up a couple of days ago."

"That could be the guy who wrote that note."

"A guy who's dead now? How did that happen?"

Nick spread his hands. "It's kind of a long boring story."

"But you came across his body and you found this note on him?"

"Right. He didn't look like a Sylvia, so I got curious."

"And if that guy hadn't died tonight, I might be dead right now?"

"It's a possibility."

Sylvia sagged against the car. "God."

"So, no one you know of has a reason to want you dead?"

"No! For that matter, did you kill this guy?"

"No. He, uh, died in a traffic accident."

"God, first my father dies, and now someone wants me dead?"

"Now. Really a rotten month. Do you know an Evan Jiffon?"

"No. That's the name of the guy who died."

"Yeah."

"Never heard of him."

"Anything unusual about this last month or two?"

"You mean other than having my father die and finding out he paid for one of those meat lockers?"

"Meat locker? You mean a cryo-crypt?"

"Yeah. Evergreen Deep Freeze."

"Evergreen. I thought if you froze hamburger, having it turn green was a bad sign."

"I don't think that's exactly the image they had in mind." She hesitated.

"I was up to see him. He had even paid for a contract for me."

"So when you die, you wind up in the freezer, too?"

"You'd make a charming undertaker."

"Sorry. I'm preoccupied. None of this is making much sense to me."

Sylvia shivered. "Take me home, will you?"

"You trust me?"

The car blared "409" as Sylvia looked at it and said, "No killer would have a car like this."

Nick wasn't too sure about that.

Nick slowed to a stop in front of Sylvia's home. "I really do think you'd be better off with some kind of protection."

Sylvia shook her head again. "I know you mean well, but I can't just bring a detective along whenever I show a house. I'll be more careful about making sure someone else always knows when I'm going out, and I'll make sure anyone I show a house to knows that a friend is keeping track."

"At least let someone guard your house. If not me, pick someone from the book, or I can recommend a couple of people."

"The house is secure. I've got very good locks, and an expensive alarm system," Sylvia hesitated. "You wouldn't go through such an elaborate con job just to get business, would you?"

"It's no con job," Nick said. He looked straight at her.

Sylvia opened the car door. "All right. I believe you. Look, I'll be careful, and if anything funny happens, I'll call you."

"OK." Nick didn't like it, but he couldn't really force protection on her.

"Good night," she said.

"Good night," said Nick.

"Close the door, will you?" said the car.

Nick watched Sylvia enter her house safely, then drove away slowly. The car said, "I could have won that race if I had good tires. How about some new HR-15s, Nicky?"

Two days later, Nick scanned the morning paper.

"Uh oh." He leaned closer to the paper and felt sick. "Damn it!"

Sylvia Harley was dead. The paper said her body had been discovered by the maid. Apparently Sylvia had slipped in the bath and hit her head hard enough

to knock her unconscious, and she had drowned. Sure, and General Motors management donated to the union strike fund.

So despite Sylvia taking more precautions, they had gotten to her. The frustration built up in Nick until he couldn't ignore it. He had to do something.

He'd visit Evergreen. He might not learn anything, but he had to make the attempt.

Nick rinsed his coffee cup, and water swirled down the drain as he briefly considered taking a cab.

As Nick drove past Fundamentally High School, a lone protester paced before the main doors. The old woman's placard read, "Put science back in education." Last week a letter on the editorial page had suggested that things wouldn't be so bad if the schools weren't turning out so many uneducated idiots. Today, probably in sympathy with the letter, someone had posted a large sign saying, "School Zone—75 MPH."

Nick pulled up in front of Evergreen Deep Freeze. The building looked more like a big old mansion than a public meat locker. The tasteful and subdued letters EDF were all Nick saw at first that told him he was in the right place. And not a block away was the parking garage the dead man had a receipt from.

At the end of a long trek up a carefully edged sidewalk sliding through a putting-green lawn, Nick saw the script lettering next to the door saying EDF did indeed stand for what he thought it stood for.

He opened the door and walked in.

The carpet felt as thick as the grass had looked. The music was soft and apparently meant to be soothing, a Muzak version of "In My Room" by the Beach Boys.

A tall man with hollow cheeks appeared through a curtain formed of tapestry strips. "May I help you, sir?" In another century, he could well have been a butler. His nose hairs made his mustache fuller. His voice reminded Nick of the voice on Jiffon's phone.

"Yes. I came to see Sylvia Harley."

"I'm sorry, sir. Only immediate family members are allowed."

"Well, I'm almost immediate family. We were engaged."

"I'm sorry, sir—"

"And I was thinking of paying for storage for myself in the event that something should happen to me."

"Well, sir, seeing as how you were so close to Ms. Sylvia. I'm Alvin Hodges."

Alvin led Nick through a doorway at the back of the house and along the corridor angling toward the rear of the lot, where a more modern building lay. Framed pictures lined the corridor wall, presumably all of them "befores." Nick recognized at least four people he'd seen on the society pages. At one of the pictures, he paused. "So Bentley Parsons is a client, too?"

"Yes, sir. His body was quite badly crushed by a hit-and-run driver, but his brain is in tip-top shape. As soon as medical science is ready for brain transplants, Mr. Parsons will be ready to come in out of the cold." Alvin chuckled at what he must have thought was a joke.

"But Sylvia won't have to wait that

long, will she?"

"I'm afraid she will, sir. You no doubt know that she drowned. As it turns out, she was found before her brain suffered irreversible damage. Unfortunately, when the rescue team attempted open heart massage, they did enough damage to her heart and lungs that, even if she were alive, she'd need transplants. Besides that, all we at Evergreen preserve is the head along with the brain stem and the upper section of the spinal cord. None of these people will be revived until medical science can replace most of the rest of the body, and until we know much more about the aging process. I hope that with the progress they're making today, they'll be revived and up and around in perhaps twenty years."

"That seems like a long time."

Alvin nodded.

They walked in silence a few paces and Nick said, "So, how long have you folks been in business? I sure wish you'd been around when my brother--"

"About a year, sir. When your brother --"

"I'd rather not talk about it."

"Certainly, sir. Ah, here we are."

Alvin led Nick through another door, this one considerably more sturdy than the first door. The room beyond was a little like a laundromat, but much colder and with no coin slots. Rows of cabinets lined the floor, and Nick could see his breath in the air.

Nick stopped in front of the first cabinet and peered through the slanting oval window at the top. "I can't see anything."

"That's where we keep the Pop-

sicles, sir."

"That's what you call them?"

"No." The man snapped the latch and opened the front of the cabinet. He withdrew a Fudgesicle and offered it to Nick.

"Oh, I see. All right. Thanks."

Nick tore open the wrapper and started nibbling on the Fudgesicle as they walked down the aisle. Dead faces stared through the frosty windows.

"Miss Sylvia is right here," said Alvin. He rested his fingers on top of a cabinet, and Nick moved closer. As Nick neared the glass, Alvin started to remove his hand from the frosty sheen on the cold cabinet top. He couldn't; his fingers were stuck.

Nick saw the man's dilemma and winced. "Here, let me help." He gave Alvin's hand a sharp pull, and the fingers came loose from the cabinet with a pitiful ripping noise. Two patches of skin stayed on the ice.

"Ah, sorry about that," Nick said.

Nick moved back to Sylvia's cabinet and noticed her name on a tag just under the oval window. The window was slightly frosty. Nick wiped away some frost and condensation and peered through the window. He sucked in a deep breath as he saw Sylvia's face, small mole and all, her eyes closed, her skin tinged lightly blue.

Nick stood up. "Why does she look so far away from the window? The cabinet doesn't even look that deep."

"For safety, the head is placed well away from the observation port. Ms. Harley's head is actually about halfway between the floor and the window, facing the rear of the cabinet. A mirror at the rear lets us see her face. We have

numerous sensors installed in each cabinet, but the observation port lets the family see their loved one, and lets us make occasional visual checks."

"Could I see her father, too? We were friends."

"Surely, sir."

As Alvin escorted Nick along the aisle, Nick glanced at more of the faces and memorized several of the other names. "What happens in the case of someone with a severe head wound?"

"Typically such victims are not candidates for Evergreen. But the lucky ones, the ones whose brains are intact, will no doubt be forever grateful to Evergreen. When they finally awake, they may well be immortal."

Nick didn't comment on the choice of the word "lucky." Seconds later they arrived at Ted Harley's cabinet. Nick saw the face from the newspaper photo, hair combed just the same way, with Harley looking as though he were just taking a quick nap. Nick wondered if sutures inside Harley's lips held them closed as if the body were at a funeral.

"God, I just can't believe they're both gone," Nick said finally.

"I know exactly how you feel, sir."

Right, thought Nick. The Muzak had switched to Simon and Garfunkel's "Sounds of Silence."

Alvin went on. "But when they awake, they will have the last laugh. They will never have felt better."

"Well, thanks for letting me see them."

"You're quite welcome. As long as you're here, you said you'd like to take a brochure that explains our services?"

"Yes, of course."

Back in the lobby, Alvin handed Nick

a letter-sized file folder full of sales literature. "Here you are, Mr. ----"

"Rice. Edgar Rice."

"Nick Naught Private Investigations," Nick said into the phone.

"Jeez, Nick. Why don't you get an answering machine? I tried to get you all afternoon," said Ricardo, a buddy of Nick's who did computer searches for him. Nick often did enough legwork that he didn't need Ricardo as much, but for the last few days he hadn't felt much like driving.

"It's a long story. What do you have?"

"I got answers back on all those names," Ricardo was a terrific researcher. Nick wouldn't have minded having Ricardo helping him with some of the actual field work, too, but Ricardo's idea of living dangerously was buying a car with a side mirror that didn't say, "Objects in the mirror are closer than they appear."

"And? Anything in common?"

"A little. They're all A-plus ratings or better."

"Makes sense. Evergreen's probably not cheap. What else?"

"They all checked out during the last year."

"OK. Evergreen's fairly new, so that's not suspicious."

"Their credit ratings are zilched out."

"They're all dead. What did you expect?"

"I know that. But credit reports usually take a while to wind down. The accounts go into an estate fund, and creditors wait in line to get fed. These folks all had major accounts at Rock

Solid S&L, and as soon as they died the account balances went into century trust funds set up for when they thaw. They're leaving enough behind to pay bills, but these people found a way to take it with them. There's no law saying a dead guy can't make money in the bank.

"Now that's interesting," said Nick. "I bet if they stay frozen long enough, they'll all be billionaires when they get out."

"If you were sure you'd come back healthy and young and rich, I can see where some people might volunteer—not even wait for an accident. I remember the days when I was a kid, and the cops would come in an hour or two if you called them. It would be nice to think that someday in the future things won't be quite so messed up. Maybe these folks thought the same thing."

Nick hesitated. "What kind of health were they in?"

The line was silent for a moment. "They're dead, Nick. Think about it."

"I know that. I mean in general were they old people near death, or people with terminal illnesses, or what?"

"Oh. Just a sec." Moments later Riccardo was back on the line. "That's funny. If their medical-insurance premiums are any guide, aside from a few people who knew they were dying, the rest were all in perfect health."

Nick did some more checking from his office that evening. Evergreen was ten months old and financially very stable. Nick tried to get info on the trust funds set up for the Evergreen residents in deep freeze, but couldn't.

He sat at his desk feeling confused. Often when he was working on a case, at some point he'd finally latch onto the key fact that made everything else start to make sense, and so far with this case he hadn't. He picked up the newspaper with the story about Sylvia and stared at her picture. She looked just like she had at Evergreen except that in the newspaper photo her eyes were open.

Nick put the paper back on the desk and thought some more. And then suddenly he was up and moving, out of the office and toward the elevator.

His car greeted him as he slid behind the wheel. "Where have you been, Nicky? It's lonely out here."

"I've been busy, OK?"

"OK," said the car. It was silent a moment. "You know, new tires would increase your gas mileage and make me a lot safer on wet streets."

Nick had to park several blocks away from Evergreen, just in case the sound from the radio carried. On the walk from the car, even though he stayed on the sidewalks, he set off a half-dozen overly sensitive car alarms that cried "Stand back from the car!" and "Stop, thief!" in his trail. A block later he passed an unoccupied Cadillac playing Wagner.

At the back of the group of Evergreen buildings was an idling hearse with no driver. Nick cautiously moved closer to the rear door of the building. It was propped open with a rock. Nick peered through the gap and saw movement. Instead of going inside, he peeled a strip of tape from a small roll in his pocket and hastily taped the latch bolt so it couldn't extend into the striker plate.

when the door closed. He moved back along the side of the building until he reached some shrubbery that would provide adequate concealment.

Minutes later the hearse driver came back out. She kicked the rock away and let the door close. Twin red taillights disappeared into the darkening night, and Nick decided he'd better play safe and wait for a while. He was pretty sure he still knew how to recognize poison ivy, and he was reasonably sure this wasn't it.

Nick woke with a start, almost like he was back in one of the boring classes he'd had in any number of schools. An ant had just bitten him on the nose. He squashed the ant between finger and thumb and didn't feel guilty in the slightest. His back was sore, and his wallet and tool kit pressed into his rear like twin tumors.

The night was dark and still, and the air smelled of the plants nearby. Nick stretched and yawned.

A single floodlight illuminated the small parking lot, which was fortunately empty. Nick reached the back door, and it opened easily.

A vacant corridor awaited. It had been thoughtfully carpeted to keep the noise down. Nick moved quietly inside and let the door close gently behind him. He could smell one of the least pleasant odors of high school: formaldehyde.

The first door Nick came to was locked, but he got it open with a credit card. Too bad the room turned out to be just a bathroom. These people must lock everything.

The next door was locked, too. Fortu-

nately this lock, also, was a blue-light special. Beyond the door lay a doctor's office, or at least it looked vaguely like one, but for the power tools near the coffin-sized operating table with gutters along the sides. A large refrigerator stood near one corner. Inside were a number of beakers, each with a different specimen floating inside. Nick was pretty sure one was a heart, but he couldn't tell a spleen from a kidney or a thyroid gland. As he closed the door, he suddenly remembered the recent *Global Inquirer* article about the woman who'd received an appendix transplant.

So, if his gut reaction were correct, Evergreen made some pocket change by selling organs retrieved before they finished with the bodies. Nick wondered if that money went into the victims' trust funds, but he suspected the answer was no. Or, as Alvin would probably say, assuredly not.

At the next door, Nick decided Evergreen must have gotten a quantity discount on locks. This room felt warmer than the others. On the far wall was the explanation. Heavy iron doors with well-insulated handles opened onto a crematorium furnace. That explained where the unused parts of the bodies went. Nick wondered if they had to abide by pollution-alert no-burn days. Lately there had been at least twenty-seven of them a month, so on the occasional approved burning day, the Sun usually disappeared by noon.

The corridor was as quiet as ever when Nick eased back into it. The door across the hall yielded to his efforts, and beyond it lay the rear of the large room Nick had visited with Alvin. Evergreen

must shut off the visitors' heat at night, because the room felt even colder than it had earlier. His breath fogged the air. He kept his head low as he moved down a couple of rows so he could sit on the floor and be out of sight of both doors.

He sat next to one of the refrigerated units and grabbed the tool kit from his pocket. The name plate on the unit identified the occupant as Morton Westhemmer. With the tiny flashlight, Nick got back to his feet and crouched next to the observation window. He wiped away frost and condensation and peered inside. The face of a slumbering forty-year-old man inside reminded Nick of one of his laziest teachers back in school.

Nick twisted on the flashlight and directed the beam inside. He moved it from side to side but the beam didn't brighten the sleeping face. Nick had a sudden thought about one-way glass and dismissed it.

Near the bottom of the cabinet was a panel that ran the width of the unit, held in place with eight torque screws. Nick used his tool and a couple of minutes later the panel suddenly sagged on one side as Nick got ready to take out the last screw. Inside the enclosure was a compressor, no doubt part of the cooling system, and next to it was an electrical plug inserted in a socket in the floor.

Nick drew in a breath, planning to remove the plug for only a couple of seconds. Surely the insulation in the unit would prevent any real damage. He pulled the plug. The compressor went right on running.

Nick looked more closely at the inside of the box. Sure enough, they had installed an uninterruptible power sup-

ply. Evergreen certainly wouldn't want to be off the air during a power failure.

He reached into the cabinet, found the recessed switch, and flicked it off. The compressor died. Rapidly Nick raised his head and peered through the observation window. He saw nothing. He flicked on his tiny light. The inside of the cabinet was empty.

"I'll be damned," Nick said softly.

"You never can tell," said a voice behind him.

Nick turned carefully, slowly, keeping his hands visible.

Alvin stood just on the other side of a row of cabinets. With him were two men who looked more like businessmen than guards, but all three men held pistols pointed at Nick.

Nick didn't stand to gain anything by playing dumb. "Holograms, huh? So this whole thing is just a big con game to get estate money from rich victims?"

Alvin said, "Actually, I thought we'd last longer than we did. But we have made an obscene amount of money already, so I guess all's well that ends well. I am curious about what tipped you off, though. I promise we'll be harder on you if you don't tell us."

Nick considered that for a moment. "They all looked just like their pictures."

"That's bad?"

"I mean exactly like their pictures. Sylvia's mole was on the same side. Ted Harley had his hair parted on the correct side."

"So?"

"So, you told me the heads face the rear and a mirror lets people outside see them. You look in a mirror and tell me if your hair is still parted on the same

side."

Alvin gritted his teeth. "Thank you, Mr. Rice. Although I don't suppose your real name is Rice."

"Naught."

"I said that."

"Nick Naught. That's my name."

"I bet that was fun growing up with."

"Oh, yeah."

One of the men with Alvin started getting visibly impatient, shifting from one foot to the other. He looked like one of the heavyweights on "Boxing for Dollars."

"Well, Mr. Naught, I guess we'd better get started," said Alvin.

"Started?"

"You don't have a car in the lot."

"No."

"But no doubt you have one close by. And we don't want it found near here. Mr. McCarthy will go with you to your car and bring you back here." Alvin indicated the impatient man with no neck.

"And why should I do that?"

"Hope springs eternal. Have you forgotten? If you don't do it, we'll kill you right now and look up your license plate number on our own. If you help us, you stay alive longer, and I'm sure that will motivate you."

"OK, let's go." Nick stood up slowly. "Just don't use any more homilies on me. I don't think I can take it."

Alvin frowned. "Just a moment." While Alvin's silent helpers held their guns on Nick, Alvin found and removed Nick's pistol. "There now. I think you're ready."

Nick trudged toward the back of the complex, trying to figure out how to get

away from the silent man following him with a gun. They went out, through the parking lot, and onto the dark street, quiet but for the sound of a few distant sirens and car radios.

They walked five blocks before the man behind him said anything. "I think you're trying to be funny. I'm not going to follow you around the neighborhood until dawn. We get to your car in ten minutes, or we don't get to it at all."

Nick stopped, then turned back the way they had come. A block later they reached Nick's car. The windows were all the way up, but Nick could easily hear "Little GTO" playing inside.

"Here we are," Nick said.

"You drive." The man held his gun on Nick as he got into the passenger seat and Nick slipped behind the wheel.

"Turn that crap off," Nick said as he started the engine.

The radio volume dropped. "Why?" asked the car.

"You'd better get used to playing something else," Nick said as he pulled into the deserted street.

"Why?"

"Because you're going to have a new owner soon, and probably no one else will put up with this." Almost anyone else would probably have the money to completely replace the car computer.

"Why?"

"Is that all it can say?" asked Nick's heavyweight passenger.

"Because this guy is planning to kill me," said Nick.

"Why?" asked the car.

"Does it really matter—" Nick was saying when suddenly an explosion sounded and the passenger-side airbag burst in the face of the man with the

and Nick slammed on the brakes and hit the back of his hand as hard as he could against his captor's temple. The man's head jerked over and snatched hard against the side window. Seconds later stuck in the man's gun in his hand. "Nice night work!" Nick shouted. "Thank you," said the car. "But don't expect to love me."

Nick reached and placed the dozen roses in Sylvia's hands.

"I'm sorry, Sylvia. No one should die for such a senseless reason. Maybe now you can at least sleep a little more."

Nick walked slowly back toward his house, breathing cool morning air. When he was about fifty yards an old woman said, "That car was that's disgraceful."

Nick stopped and then talking about the man. "I know 'Man's Curve' sleeping in the back of the car doors and windows. I was stuck in the hands helplessly. The car was slow at him as he walked."

Nick was depressed about Sylvia's death, but he did feel a sense of accomplishment in getting

Evergreen shut down. The police had actually arrived fairly promptly, and Riccardo had been able to verify that all the trust funds set up for the victims at Rock Solid S&L had been funneled into Evergreen. Alvin and his friend would be in a different kind of deep freeze for a long time.

"So, Nick," said the car. "What about that new fuel injection system?"

"Give me a break. Weren't the new tires enough? How long am I going to have to pay?"

The car was silent for a moment. "I know your MasterCard number."

"God," Nick massaged his temples.

Seconds later, a deep rumbling sounded from behind the car. In the rearview mirror appeared a huge band of mean-looking bikers. The two guys in front had so many tattoos their skin looked like blueprints. Chains hung from their necks, and pieces of food were stuck between their teeth. Or maybe those were bugs stuck in their teeth. A few more bikers sped past before the car said innocently, "Come on, Nicky. You wouldn't want the horn to stick, would you?" ■

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The Alternate View

CENTRIFUGAL FORCES AND BLACK HOLES

John G. Cramer

This column is about forces and pseudo-forces. In particular, it is about the surprising thing that happens to centrifugal force in a very strong gravitational field, as recently discovered in the formalism of general relativity by M. A. Abramowicz and his coworkers. Everyone, of course, knows about centrifugal force. It's the force that pushes you away from the center of the turn when your car goes around a tight corner. If you tie a rock to a string and swing it in a circle, it's the force that pulls the string tight and slings the rock away if the string breaks. It's the force that pulls the water out of your laundry when the washing machine is on the spin cycle. And it is the force that balances the pull of gravity and holds the Earth in its orbit around the Sun.

What perhaps you did *not* know is that centrifugal force is, strictly speaking, not a force at all. It is a pseudo-force. It is, in a sense, an illusion produced by changing coordinate systems. This is a slippery idea which will require some explanation. So to understand why centrifugal force is *not* a true physical force, let's start by considering what the true forces of nature are.

There are four fundamental forces, the strong and weak interactions that

govern the behavior of quarks, nuclei and radioactive decay; the electromagnetic force which governs light, electricity, and chemical reactions; and the gravitational force which keeps us stuck to the surface of our planet and governs the behavior of planets, stars, and galaxies. Of these forces, gravity is by far the weakest, and the strong interaction, as its name suggests, is the strongest.

Each of these fundamental forces has its own "mediating particle," a particle that is pitched back and forth in a quantum-level game of catch between interacting particles. For the strong interaction the mediating particle is one of the eight varieties of *gluon*; in the weak interaction it is one of the three *weakons* (the Z^0 , W^+ and W^-). The mediating particle of the electromagnetic interaction is the *photon*, the basic quantum of light discovered by Planck and Einstein. The mediating particle for gravity is the *graviton*, the basic quantum of the gravitational radiation (gravity waves). Gravity waves, however, have only been observed rather indirectly as they steal energy from a binary neutron star, and the graviton itself is a theoretical construct which may never be observed directly.

The four forces each have a characteristic distance or "range" over which they act. The weak force has the shortest range, about 10^{-18} meters (.0004 of the diameter of a proton). The strong interaction's range is about 10^{-15} meters. Both forces drop rapidly to zero when interacting particles are separated by a distance greater than the range of the force. Effectively, the strong and weak forces switch off outside their range.

Electromagnetism and gravity have an infinite range, and so they never switch off. Both forces fall off as $1/r^2$ with distance, diminishing with distance but never going to zero. Because gravity extends over large distances and because it accumulates in strength with contributions that always add, ultimately when enough gravitating matter is present the effects of gravitational attraction can overwhelm those of the stronger forces. The supernova and the neutron star are examples of systems dominated by gravity, in which the ac-

tions of the electromagnetic, strong, and weak forces are nullified or even made to work backwards under the influence of very strong gravity.

With this background, we can see why it is not correct to call centrifugal force a force. It has no mediating particle. It has no range. It has no place setting at nature's table of the forces because it is an illusion, a pseudo-force that is the result of inertia. Newton taught us that mass, once moving in some direction with some velocity, will continue to move in a straight line in the



Illustration © 1992 by William R. Warren, Jr.

same direction with the same velocity unless some external force bends its path, speeds it up, or slows it down. This is inertia, the underlying principle that produces the centrifugal force effect.

If you are in a car that turns a corner, it is the action of inertia that causes your body to try to continue in a straight line. Forces exerted by the seat, the seat belt, the doors, etc. are required to push your body in the new direction. Thus you have the illusion, because your point of view is in a reference frame that is being accelerated in a circle, that some external force is pushing you away from the center of the turn. There is no such force. What you actually experience is inertia trying to continue your motion in a straight line while the interior of the car around you is moving in the circular path of the turn.

It was the subtle connection between inertia, centrifugal force and gravity that Albert Einstein called the Principle of Equivalence and used to establish an entry point for developing the general theory of relativity, the present standard theory of gravity. Think of the equivalence principle as a TV quiz show. The contestant is anesthetized and placed in a sealed but well equipped and environmentally controlled box. When he regains consciousness, he is asked to determine on the basis of any measurements he can perform inside the box whether (a) he is at rest on the Earth in a 1 g gravitational field, (b) in gravity-free space and being accelerated in a straight line with an acceleration of 1 g, or (c) moving at a constant and very high speed along a circular path of very

large radius so that the centrifugal force is 1 g.

Einstein's working hypothesis, as embodied in the equivalence principle, is that the contestant's task in this game would be hopeless. There is no possible physical measurement that he could perform within the box that would distinguish among these three conditions. The effects of gravity, as they are experienced at rest on the Earth (condition a) are indistinguishable from the effects of inertia as experienced in linear acceleration (condition b) or in circular motion of sufficiently large radius (condition c). This, Einstein said, is because mass distorts the geometry of space itself to produce gravity, which at its root is just another manifestation of inertia. Gravity and inertia are the same.

Centrifugal force is present when a mass moves at a uniform speed in a circle, but it is absent when the same mass moves at the same speed in a straight line. But what, in a universe where space itself can be curved, do we mean by a straight line? Einstein's answer was to use a beam of light as the surveying instrument that determined which lines are straight lines: whatever path light takes is what we mean by a straight line.

In gravity-free space this is obvious. Near a massive star or a black hole, where light itself can be strongly bent or even trapped by gravity, it is not. With G as Newton's gravitational constant (the strength of the gravitational force), a black hole of mass m has a characteristic radius $r_s = 2Gm/c^2$ called the Schwarzschild radius at which the escape velocity equals c , the velocity of light. This means that at r_s ,

light itself cannot escape that gravitational pull of the black hole. At a radius half-again as big— $r_c = (3/2)r_s$ —light will be so bent by gravity that it will travel in a circular orbit around the black hole. At just this radius r_c , space is bent so that the “straight line” path traveled by light becomes a perfect circular orbit.

M. A. Abramowicz and his coworkers have recently investigated the effects of centrifugal force in the vicinity of r_c . They have found a remarkable result: inside a radius of r_c the centrifugal force acts *backwards*, pointing *toward* the center of turning. In other words, instead of the centrifugal force slinging an orbiting object outward, it will push the object inward.

A standard Keplerian orbit in a weak gravitational field can be thought of as a delicate balance between the force of gravity which pulls the orbiting object toward the center of attraction, and the centrifugal pseudo-force which pushes the orbiting object outward. If the centrifugal force changes sign and points inward, there can be no stable orbits. Any matter that wanders inside the zone bounded by r_c will immediately fall further inward.

This result is not so surprising when we consider that at the radius r_c light travels in a closed circular path. This is the equivalent, for general relativity, of a straight line and a mass traveling along the path of the light beam, at whatever velocity, should experience no centrifugal force, any more than it would in traveling in a normal straight line in gravity-free space. It therefore becomes reasonable that when we venture even deeper into the gravity well

the curvature of space will increase even more, with the result that a mass traveling in a smaller circular orbit experiences a negative centrifugal force.

The significance of this result relates to the problem of observing black holes. The black hole, being intrinsically a trap for light, cannot in itself be observed optically. However, particularly when the black hole is one member of a binary star system, there is expected to be an *accretion disk*, a very hot disk made of gas and dust that is in the process of releasing its gravitational energy as heat as it falls into the black hole. This material becomes so hot that it provides a bright beacon in the ultraviolet and x-ray regions of the electromagnetic spectrum pointing to the locations of binary systems with black holes.

Previous computer simulations of the behavior of the accretion disk have indicated very peculiar behavior inside a radius of r_c . Very strange distributions of momentum and angular momentum were calculated. Long ellipsoids of gas became spherical and the direction of flow mysteriously reversed as the viscous gas fell into the black hole. With this new insight provided by the reversal of the centrifugal force, this behavior becomes clearer. Inside r_c the same forces that had stretched the gas into an ellipsoid force it toward a spherical shape.

The radius r_c (which is 50% larger than the Schwarzschild radius) is of special significance in the dynamics of black holes because it is within this boundary that the black hole becomes a matter-eating vortex with no stable orbit

possible. We can ask, in the spirit of Larry Niven and Bob Forward who have conjured up heroes that orbit their ships close to neutron stars and black holes, whether it is possible to venture within the zone bounded by r_c .

The answer, given a sufficiently powerful engine, is yes. The hero would have to point his engine always inward and at right angles to the direction of

motion, balancing with engine thrust both the gravitational attraction of the black hole and the now-reversed centrifugal force that would be pulling him inward. If he could manage this and at the same time avoid being disintegrated by the tidal forces near the black hole, he might live to tell the tale. And that is a tale that I'd like to read somewhere, sometime. . . .

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●One of the things that concerns me is the persistent tendency to emphasize too heavily . . . the importance of relationships between universities and industry as a means of getting ahead competitively. The validity of this linkage is far from clear. If universities are really the key . . . why did we grow faster than other countries during the late nineteenth and early twentieth centuries when our universities were mediocre, and why is our productivity lagging behind other nations now that our universities and their scientific achievements lead the world?

Derek Bok, in *The Changing University*

Probability Zero

C-CHANGE

Charles Sheffield

It was early in 2043 that Hippolyte Martin discovered the trick that increased the speed of light by a factor of sixty million.

Since his work began as pure theory, he checked for the usual pitfalls. Had he divided an equation by zero, or subtracted infinite quantities from each side, or taken the wrong branch of a multiple-valued function?

He had not. His work was without flaw—and translatable from theory to practice. Most staggering of all, the change in light speed could be *universal*. Everywhere would be affected once

his device was in operation.

Hippolyte was a reasonable scientist, so he sought the validity check of peer review. He published his work—or tried to. But he made the mistake of stating the consequences of his discovery, rather than offering pure theory.

He noted that the center of the Galaxy was about thirty thousand light-years away. After the c-change that would become five light-hours. Even with ships hobbling along at one-hundredth of light speed, the whole galaxy was just a few weeks across. As for visits to the nearest stars, it was hardly worth taking

along a change of clothing. Sirius and back, even allowing for the tedious business of acceleration and deceleration, was an afternoon jaunt.

Hippolyte made these points in his paper's introduction. The rejection letters ranged from studiously polite to suggestions that he needed psychological help.

Lesser men might have despaired, become enraged, or turned misanthropic. Hippolyte, fortified by the knowledge that he was right, did none of these. He assembled his c-change generator on board his spaceship, a little one designed to putter along at only a thousandth of the speed of light. For Hippolyte had a way to silence the skeptics: he would turn on the generator, head for the stars, and return with proof.

His work might be accepted before his return. Newly-generated light would be affected, while light already on its way somewhere would not; so there would be immediate visible results. The Sun was eight minutes light-travel time from Earth. When the c-change was made, for eight minutes there would be two Suns in the sky. One of those Suns would be "old" light, sent out eight minutes earlier; the other would be newly generated light, zipping from Sun to Earth in a few microseconds.

There would be similar effects all through astronomy. For forty minutes

there would be two Jupiters; twin Saturns would last twice as long. Alpha Centauri would shine in duplicate for four years, Sirius nearly nine. The new sky would be cluttered, twice as bright and populous as before, but would return to normal over years and centuries as doppelganger planets and stars vanished, one by one.

Hippolyte turned on his generator. As expected, the sky showed twice as many stars. He headed for the brightest one.

He was back ten days later, a shaken man. Earth was waiting, just as shaken. Computers, control systems, and other advanced electronics had all become pieces of instant junk. For light is just one form of electromagnetic radiation, and when its speed is changed the other forms change with it.

On the fourth day, people had remembered Hippolyte's "impossible" theory. They noted the disappearance of his ship from the solar vicinity. When he returned he was promptly charged with forty-nine civil offenses and eighty-six military ones.

He didn't seem to care.

"I wanted to give us the stars," he said. "So I built the generator. I'm sorry about the electronics. But it's not important."

His panel of judges boggled.

"Not important!" said the senior inquisitor. "Not important, to ruin the

world's economy, to destroy the banking system, to reduce to a shambles the computer and communications systems."

"Not important," repeated Hippolyte. "You see, *they* are *there*. Just the way we imagined they might be. Advanced civilizations, millennia old, *millions* of years old, across the stars and galaxies."

"On my fourth planet I met their delegates. Three beings, all oxygen breathers. They treated me very nicely. They explained about the Intergalactic Trading Federation."

"He is mad!" exclaimed the panel's expert on the non-existence of extraterrestrial intelligence. "It can be *proved*, by rigorous arguments, that interstellar commerce is impossible. In fact, regular interstellar travel of *any kind* cannot be accomplished. The distances are too large, the travel times too extreme."

Hippolyte nodded. "I wondered myself how intergalactic commerce operated over such times and distances before the exchange. Yet they were *there*." He stared bleakly at the panel. "Is there by any chance an astronomer among you?"

The others turned to a pale woman with red hair, who jerked upright at becoming the center of attention.

"You, madam?" asked Hippolyte. "You must have noticed astronomical

effects. What was your explanation for them?"

"We noticed that every light source *less* than a hundred light-years away appeared in duplicate. Anything *more* than a hundred light-years away did not; but we had no explanation."

"Then I, reluctantly, must give one," Hippolyte sighed, and turned to face the cameras. "I increased the speed of light, and thought I had made the change to the whole Universe. What I did not realize, until the beings who greeted me explained, was that the speed of light is *already* sixty million times as big as the old Earth-measured value. It has the higher value everywhere, except within a hundred light-years of Sol."

"And even *within* that hundred light-year sphere, the speed of light had its high value until ten thousand years ago. Until, in fact, the intergalactic federation had a first good look at *humans*. That was when they put in the slow-speed barrier."

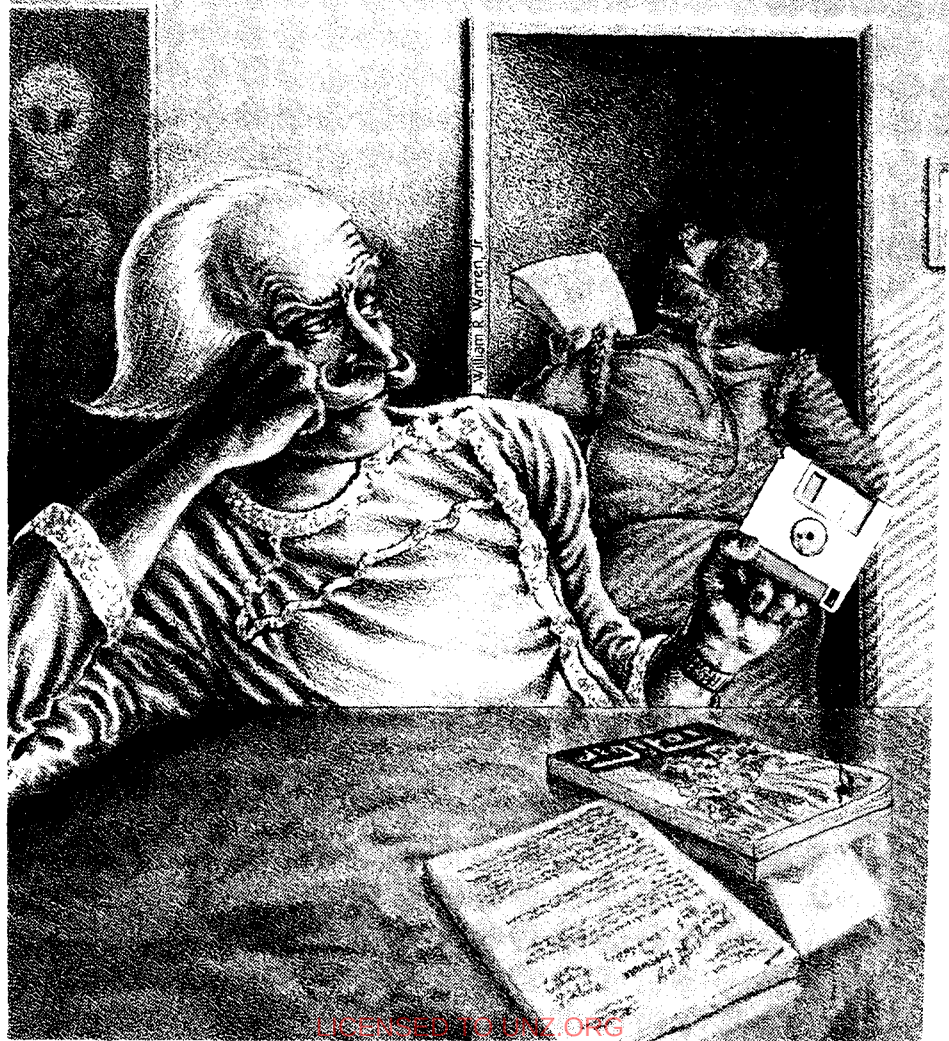
The panel was stunned to silence. Finally, the senior member spoke. "But you changed all that, didn't you? With your generator, we can go as fast—"

"No," Hippolyte shook his head sadly. "They are sorry, but they can't risk it. The Sol region goes permanently back to slow-speed—tomorrow." ■

P. C. SOFTWARE

G. David Nordley

There are both advantages and disadvantages to having a machine do your work for you...



RELEASED TO UNZ.ORG
ELECTRONIC REPRODUCTION PROHIBITED

Mr. Prescott, I think the time has come for us to have a little talk."

George was concentrating, trying to figure out whether the October cover was showing just a little too much anatomy for current tastes, or not enough for current sales. So he first noticed that Brenda had said *something* to him, and only later managed to pull what it was out of his rapidly evaporating short-term memory.

"Ahem. Ah, Ms. Steinherz, what is it we need to talk about?"

"I am uncomfortable with the atmosphere of this office."

Mr. too. But breathing smog is one of the privileges of editing a magazine in Los Angeles. Immediately, he wished he hadn't said that. It just came out. Brenda's elephantine leg stomped and she shook her head so hard George feared for her short, curly, red perm.

"If you don't start taking me seriously, I'm going to file a complaint!"

He grinned. Even if he convinced the sexual relations arbitrator that he was innocent, he'd have to go through months of hearings and a probable suspension of publication. He couldn't afford that—but if he didn't sell his house and get a good lawyer, he'd never get another job. Of course, as a bankrupt. As you, case scenarios ran through his mind, he remembered that he had an illegal target pistol. Just stick the barrel in your mouth, slanted a little up, squeeze the trigger and no more problems. Fortunately, he'd kept clear of marriage and there were no children dependent on him.

Comforted by knowing that he had at least one way out, he returned his attention to his copy editor, who was

probably trying to figure out the reason for the manic grin on his face.

"But, I do take you seriously, Ms. Steinherz, very seriously. I just thought about this smog and hot air when you mentioned the word 'atmosphere.' Uh, just what did you mean?" What could he have possibly done to her? Did he appear to notice her cleavage at the last Christmas party? Did she think that he told a gender specific joke in her presence? Not fair! He constantly struggled to keep humor out of the work place. He knew there was no such thing as safe humor anymore.

"I mean," she said slowly and deliberately, emphasizing every syllable, "the rampant sexism you expect me to copyedit and dump to the factory every day."

"But the authors—" Many of whom were women.

"Don't hide behind the authors, damn it! You buy the stories so they're yours. You can change any and every word. Don't you realize that forcing me to help publish references to MANKind, exploitive verbal pictures of naked women, stories that objectify women by calling us 'female,' and so on, is offensive? And there's all this scientific stuff. You men won't even *let* women be scientists and then you buy all this stuff that people can't understand unless they are scientists. That's sexist. Astrology and sympathetic magic are part of an organic, nurturing world view that is just as valid as all this male science. But not here, oh no. Must I help forge my own chains? Hell, no!"

He almost said "no one wants to chain you" but thought better of it, just in time. Desperately, he tried to think

of something he could say that could not be taken amiss. It was useless to argue that some of their stories described naked men as well as naked women, or took scientific and alien points of view in which humans were reasonably described as male or female, or that, after all, the magazine was a science fiction magazine. No, that would just add fuel to the fire. The right thing to do was to lie on your back, wave your legs in the air, and wait for the tormenter to go away.

"I'm sorry," he finally said. "I didn't know you felt that way. I'll try to do better."

"I sure hope so, because if I see any more of that, you've got an SRA complaint on your record!"

"I hear you." George gestured to a stack of disks. "Look, you don't want to see these the way they are now, and there's nothing else to do. So, why don't you take the rest of the day off, Ms. Steinerherz? I can finish up here."

"Oh. Why, thank you. Sears is having a going out of business sale, and I can get there early. I think my carburetor has been acting up, and I need a set of metric wrenches to work on it."

"Of course. Good shopping, Ms. Steinerherz."

He must have exhaled for a minute after she left the office. He had a finger of V.S.O.P. from the flask in the bottom left drawer of his desk. Then he picked up the phone.

"Karen, this is Mike Prescott. . . . Fine, how are you? . . . Look, at the last con you were talking to me about some expert system software that could be trained to do editing. Do you think that could be trained to recognize and

rewrite sexist language? . . . I'm in trouble with my copy editor and . . . Yeah, I know she is, but she comes to work on time. . . . A demo? Great! . . . Yes, I have the time now; this day is shot anyway. I'll be right over."

"You don't need to worry about me, Mike. I burned my NAW membership card ten years ago." Karen laughed heartily. A tall, thin, black woman with owlsh silver-rimmed glasses, her software company was always struggling and she was often short on funds, but on good nature, never.

"Thanks. It's getting so that every day in the office is a minefield. I get so tight, I have to wear a neck brace. Brenda Steinerherz isn't that bad a copy editor, really. She gets the work out. I just need to defuse this sexism thing and give myself a little breathing room. What I was looking for was some program she could train, so it would highlight and rewrite the stuff that sets her off."

"Whoa now. The rewrite part may take some doing. Is she consistent?"

"I'm not sure. I'm hoping that if I can just filter out most of the irritating stuff, what leaks through won't irritate her that much."

"Uh, huh. Well, first let me show you WordOut. California's been using it since 1998 to make sure their license plates don't have objectionable words. It checks homonyms, non-standard spellings and even missing letter variants."

"I need that, but it's not just words, Karen. Some complicated phrases can be objectionable, too—and contextual

situations. Like with 'ladies.' It's OK for a story to mention someone in a Ladies Professional Golf Association event, but a male character can't come up to them and say, 'hey ladies.' To Brenda, that's a condescending, white glove stereotype.

Good grief! What does she want? Hey, you guys!"

George smiled. "You're getting the picture."

"Huh. Let's see what kind of data bases are available on line." Karen tapped the screen of her Granny Smith with the eraser end of her pencil a couple of times and the machine started searching.

After a few minutes, they located the National Association of Women's *Monthly Dictionary of Sexist Words and Phrases*. The entry on "female" made his eyes pop. There were twenty different situations alone in which "female" was considered sexist and only three in which it was politically acceptable: including when used by a woman or when used by anyone in a strictly biological context. The whole file would have taken twenty minutes to down-load, so he ordered it on compact disk.

"Now," Karen told him, "we need a good political pattern-recognition word-processor. Like REVISIONIST." She tapped her stylus on the menu screen twice and a specialized desk top appeared. "We got an old World War Two book on disk. What we can do is scan through, look for any references to 'disabled veterans' and change them to something like 'physically challenged victims of imperialist war policies.' It will consider passages as long as a paragraph as an case.

Mike watched the program pull up: "... and other veterans of the Japanese attack on Pearl Harbor who were disabled as a result of injuries sustained . . ." and change it to "... and other victims of the reaction to US imperialist interference in Asian affairs, who became physically challenged as a result of injuries sustained . . ."

"Not good," he said, "but not bad either. Looks like it could handle sexist language, all right, but I'd like it without the Marxist doublespeak."

"No problem: that's just a data function. Just think of the program as a black box. Text and data bases go in one end, politically correct language comes out the other. I'll let you have it on trial, for a week," Karen smiled. "There's even a weekly data base update service, linked to all the interest groups. We subscribe to the NAACP's for instance so you know whether to call me African-American, a black, of color, or Negro, and when. By the way, you can spell out that acronym, NAACP, again. It's OK this month."

"Karen, I think I'll just call you beautiful."

"Any day, honey." She put her hand on his arm and gave him the best smile he'd had in a week. He let himself dream for a moment, but she was a head taller than he was. It would never work. He patted her hand, then got up to leave.

"Thanks for the help. I have to do something about this situation tomorrow, or I'll lose my mind."

"If you do, I'll sell you a new one," Karen laughed.

"Ms. Steiner," he said the next day. "We are going to have to cut ex-

penses. I'm reducing both of our salaries 10 percent."

"You can't do that! You're doing this just because I challenged your sexist editorial policies. I'll complain to the arbitrator!"

"Just a minute," Mike smiled. "That's just to keep the accountants happy. The next thing I'm going to do is appoint you to our new associate editor position, with a ten percent salary increase!"

"Oh! I guess that cancels out, then. Well in that case . . . but what will I have to do?"

"You need to teach the new computer program I got how to recognize sexist language. Something that I'm obviously no good at all. To make up for the time, I'll go ahead and send the text to the factory myself and answer the mail."

"Oh. OK. I can do that. But what about the content?—All that science stuff?"

"I'm afraid I can't budge on that. After all, this is a *science* fiction magazine. That's what writers send me. I can't rewrite it well enough; if my stuff sold that well, I'd be writing best-selling novels instead of doing this!" In fact, it was the royalties from his novels that let him do this job at all—but flattery never hurt a sales pitch. "I've seen your stuff and I think you can do it better."

"Well, we'll see." She actually smiled at him. Gold fillings. "See, I'm not unreasonable."

Mike sighed in relief. The transition period had its rough edges, but to give the devil her due, Brenda gave him a chance and didn't file her complaint.

Both he and Brenda worked overtime at the start, but pretty soon the computer program was correcting Brenda's sexist stuff well enough to satisfy her. And the software was so fast she was going home early every day.

But happiness lasted just long enough for the March issue to be seen by its authors, who were livid. But more worrisome were the two hundred subscription cancellations that month. George polished up his resume, and stayed up nights doing a rewrite on a long delayed novel with a state-of-the-art grammar checker. The thing still was pretty dumb about context, but . . . One morning, as he turned in for an hour's sleep before hitting I-405, the thought occurred to him that grammar was patterns. Learned patterns.

"Tell me one more thing, Ms. Steinerherz," he said with forced cheerfulness after his commute.

"Yes, Mr. Prescott?"

"Do you ever read our magazine? I mean after it goes out?"

"Why should I? It's too expensive, and besides, I've already read it here."

"Just as I thought. You're a very intelligent la . . . ah, woman."

"What's so remarkable about a woman being intelligent, anyway? Just watch it, buster."

"Didn't mean anything," Mike said quickly. "I was just trying to be nice." She still frowned at him.

Mike started staying late. He built his own version of REVISIONIST, one that would keep a history of all the grammar and punctuation changes Brenda made as well as her political changes. He inserted deliberate errors and it remembered how she changed them. Then he

created yet another version of REVISIONIST without Brenda's politically correct data. He ran back-up disks of the authors' submittals through this version, and what he got out was grammatically improved, but politically still what the authors sent him.

Then, when he was satisfied, he started dumping *that* version to the factory. The politically corrected disks which Brenda gave back to him piled up in a drawer. He just barely made the September issue on time, and so narrowly avoided being lynched at that year's Worldcon. But the next issue was done a week early. And by December, subscriptions were up again.

Since he was staying late, he came in late, too. Soon he was down to seeing Brenda a couple hours a day, around noon. The tension level came way down, and in a couple of months he stopped wearing his neck brace. REVISIONIST got to be so good an editor that he even had time to do some writing of his own, and time to find out that Karen really didn't care that she was a head taller than he was.

Brenda, of course, was now spending her six hour or so a day at eight hours' salary doing nothing that resulted in anything. This didn't bother him: the magazine was making enough money to support both of them, and since she thought she was getting her say about everything, she never complained.

Then one day she came in holding a copy of the magazine, jaw set, eyes flaming.

George held his breath.

She waved it at him.

"The cover price is up and my salary isn't. What are you going to do?"

Slowly he reached for the magazine. She held onto it.

"Maybe I can get another hundred a month for you."

She stared him in the eye in a way that told him, she knows, she knows. Then she looked around at the computer she only needed to use four hours a day, the clean office, the awards on the walls, and her name plaque with the "assistant editor" title on it. The pattern of her life.

"All right. Just make sure you get it for me." She gave him the magazine with a quick smile and waddled back into her comfortable lair to go through her comfortable motions.

The magazine was dog-eared and obviously read.

He never heard about the issue of sexism from Brenda again. But, he thought one evening as he dumped an issue to the print factory, it wasn't true that she was doing nothing to earn her salary. Her copy editing expertise was fully resident on REVISIONIST, working for him every day. It was only fitting that she continued to be paid for a contribution, which, like that of a factory worker who taught a robot, or an author of a book, continued to produce value long after the original labor ceased. After all, her expertise was why he'd hired her in the first place, and if it now resided on a hard disk instead of gray jellyware, what difference did that make? ■

THE BIG OIL LIFE

Greg Coseman



Any resemblance to our
society is, of course,
purely coincidental...

Jason Thackeray was a cheerful man in a dour and sober age. Oh, he lived the same life as anyone else: like all the rest, he rose in the early morning and ate his decaffeinated breakfast. He got in his car, put his mouth to the breathalyzer to prove he was Clean, drove to the Blue Line station, and parked. Like anyone else, he rode the train, watching the engineer through the transparent observation booth as the man inserted the needle in his arm so the computer could check his blood. Like anyone else, he'd enter the office through the metal detector, and go behind a Privacy Shield to donate a specimen of urine. And like anyone else, he'd work a full day and go home to the deratiocinated pabulum that passed for public entertainment on the box.

But there was this difference about Thackeray: he loved his life.

To most folk, the notion would have been strange: life was earnest, life was purposeful. Enjoyment was beside the point and possibly subversive. One strove through school, university, working years to get ahead, to earn enough to put one's offspring through school and university. The modern world was tough, competitors domestic and abroad striving as hard or harder. Work was the human condition, and there was no joy in it. It was merely necessary.

But Thackeray was different. Where others drove with frowns of concentration, listening to self-improvement tapes, Thackery sang to the songs on the radio. On the train, everyone else clacked at palmtops, getting in some work early or reading the news download; Thackery smiled at complete

strangers, told jokes, struck up conversations. Since the maglev trains were silent, and there was little else to listen to, his persiflage often had the whole car smiling by the time he reached his destination. He was that charming.

At work, the line would file forward past the pharmaceutical hygiene officers, everyone serious, quiet, ready to hand over their specimens—except for Thackeray, who had actually made friends with those dour and petty officers of the law. He'd greet them with a cheery, "Good morning," ask after children and spouses, discuss the sports events of the previous day or the change in weather.

And as he strode through the office toward his desk, he'd greet everyone by name, stop for a chat, leaving a trail of smiles and lifted spirits in his wake.

In all that dour and purposeful business, he was the only happy man. And that was almost enough; the business was just a little less dour and purposeful than the rest of the world, its workers just a little more content.

Jason would even, during his breaks, flirt with the women of the office; and, an amazing thing, never once was he sued for harassment, accused of Eye Rape, or spritzed with a defensive can of mace. Few other males of his generation could say the same, but then, few even dared to attempt flirtation, for they knew it was not only offensive, but morally wrong, politically incorrect, and frivolous besides.

Jason Thackeray was not a noticeably handsome man—crooked nosed, balding, a little on the heavy side—yet his smile, his light-heartedness, and his charming manner were enough. Half

the women, and a portion of the men, were in love with him.

Jason Thackeray loved his job. He was in sales, an occupation that suited him to a tee. He could charm an order from the most reluctant distributor, payment from the toughest account, understanding from the nastiest of customers. Yet he viewed the people with which he dealt not, as many salesmen do, as marks to be fleeced, but as friends. He would follow them from job to job, keeping in touch even with those who left the field, offering assistance when they needed it. His customers felt a fierce loyalty to Jason Thackeray, a loyalty to which his employers were not insensate; hence, they felt a need to retain Thackeray, and paid him highly.

In a dour and sober age, Jason Thackeray was a brief, bright light; for Jason Thackeray was high on life.

But all good things must come to an end.

It was on a March day that the narcs came for Thackeray; faceless, face-shielded men in black leather, bearing automatic weapons, striding through the office past frightened suits. They cuffed him and dragged him out. Even Thackeray was hard put to remain cheerful.

In his wake, fearful people gossiped. Who would have thought it of Jason? And what had it been—a furtive sip of high-octane tea? A puff of lung-destroying tobacco? A glass of smuggled wine? Surely it could not be heroin or cocaine, drugs so despised that it was thought dangerous merely to whisper their names, lest the omnipresent cameras and microphones of the narcs take notice.

But in truth, it was none of these. Because Jason Thackeray was high on life.

“What am I charged with?” Jason asks.

“We don’t have to tell you,” says Cop One.

“Where are you taking me?” Jason asks.

“You have no right to know,” says Cop Two.

“I want a lawyer,” Jason says.

“You don’t deserve one,” said Cop One.

“Addict scum,” adds Cop the Twain.

And it is so.

Bands of steel-strong plastic bind suited Jason to his chair at wrist and ankle. The room is incongruously familiar; a doctor’s office, with degrees on the wall, white-enamelled machines of unknown purpose, a heavy wooden desk. A bushy-eyebrowed, lab-coated man studies a holotank and a sheaf of papers.

“There must be some mistake,” protests Jason, his voice revealing the strain. He is a prisoner of the narcs; his life isn’t worth a plugged ecu. There *must* be some mistake. He is Clean. He loves his life, he would never risk it for the pleasure of some minor high.

The doctor sits behind the desk, folds hands, frowns. “There is no mistake, Mr. Thackeray,” he said. “You’re an addict, all right.”

“No, no,” says Jason weakly.

The doctor nods. “You see, Mr. Thackeray, you’re high all the time.”

“I’ve never used any drug,” says Ja-

son vehemently. "Not nicotine, not alcohol, not caffeine or cannabinal; oh, aspirin, certainly, but that's still allowed."

One bushy eyebrow rises. "Not so much as a sip of wine?"

"Alcohol was outlawed before I came of age," says Jason. "My family was very strict."

The doctor looks back at his display. "It's not important," he says. "Your problem isn't drugs."

Jason nearly faints with relief. The Bill of Rights might still apply. "It isn't?"

"No," says the doctor, half to himself. "You're an addict of another kind." He leans forward. "You see, Mr. Thackeray, your lab tests show there are elevated levels of certain endorphins in your blood stream. They act as opiates on the brain. You are permanently and irrationally cheerful, Mr. Thackeray. You're always high."

Thackeray blinks. "I'm just a cheerful sort of guy," he says. "That's no crime."

The doctor stands up. "On the contrary, Mr. Thackeray," he says. "An opiate is an opiate. Endorphins are necessary to the proper functioning of the body, but your levels are way out of line. There's little difference between the action of these chemicals on your brain and the action of heroin, say. It would be inconsistent and unfair to per-

mit one and not the other."

"Then that's it?" says Thackeray brokenly. Will it be a single shot, fired unexpectedly, to the base of the brain? Or will they lobotomize him, tattoo the addict's "A" on his forehead, and set him to sweeping some public place?

"No," says the doctor, approaching with a device that looks a bit like a staple gun. "Your condition can be cured."

Jason Thackeray is a man like any other, in this dour and sober age. He rises every morning, eats his decaffeinated breakfast, rides soberly to the station, works on his palmtop on the way. He barely notices the staff as he walks to his office, intent on the day ahead; his phone conversations and sales presentations are brief, serious, focussed. "Top notch," says everyone sadly, not quite understanding what has changed.

They gossip still about the day the nares dragged him away, but the management has told them that everything is solved. So Thackeray's reputation, while not quite intact, at least has not been destroyed.

Under the skin of his arm is a subcutaneous phial. It releases something into his blood, a little each day. It keeps Thackeray Clean. He is high no more.

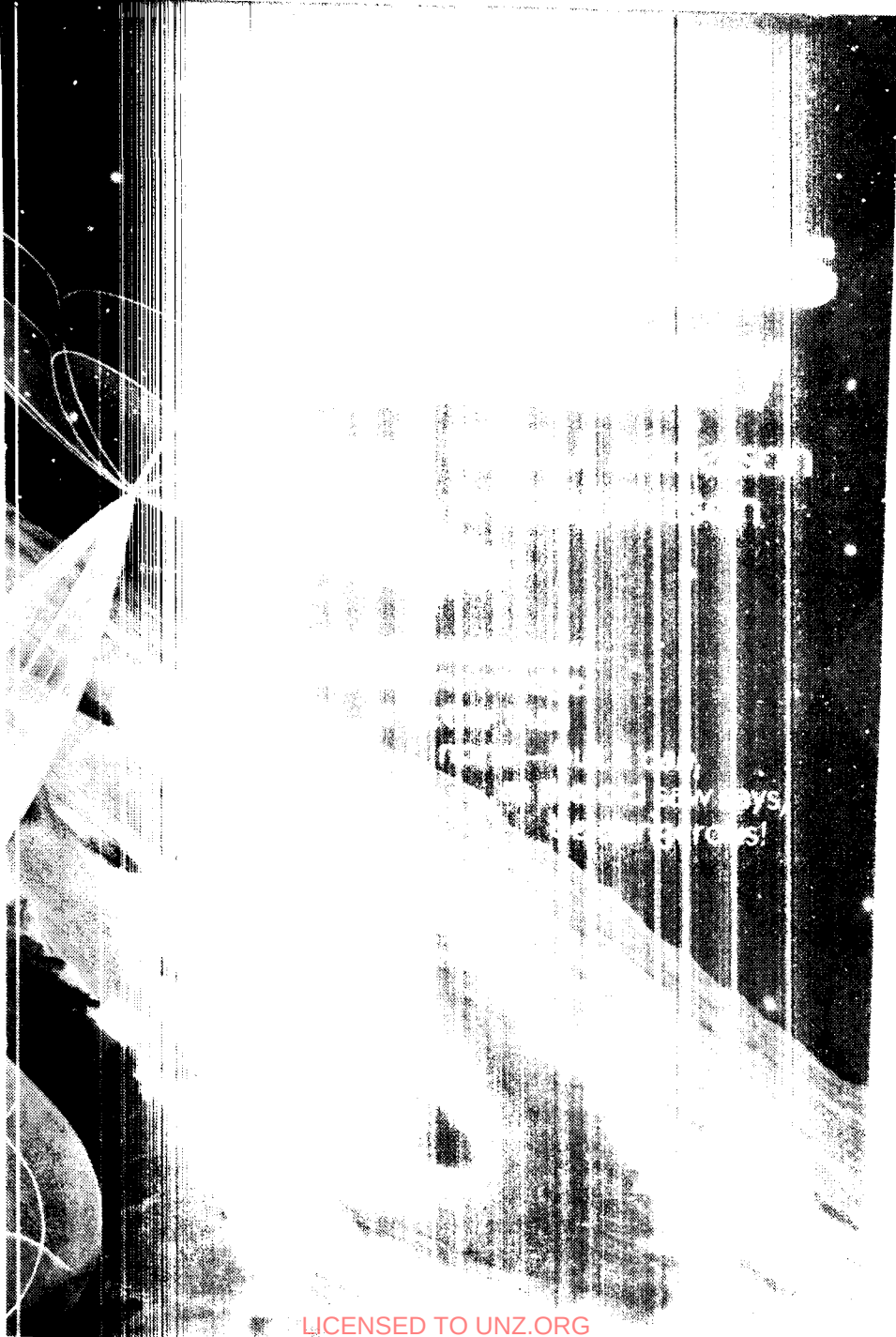
One more Addict has been reclaimed for society, one more victory won in the eternal struggle against darkness. ■

● In literature, as in love, we are astonished at what is chosen by others.

André Maurois



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SYNOPSIS

Three technicians travel to the far side of the Moon to find out why a very low frequency array designed to function autonomously has malfunctioned. At the site of the array, Daedalus crater, they discover a giant excavation project, gossamerlike frameworks, the foundations of something enormous, something no human has ever built. No one has suspected it was there. The technicians radio back to Moonbase Columbus, just before they are disintegrated, as the people at the base watch.

Jason Dvorak, architect and new commander of the moonbase, works with engineers **Lon Newellen** and **Cyndi Salito**, calling up maps of the Daedalus site. He finds that the topography has greatly changed since the last lunar mapping photographs.

Dispatching a telepresence probe to the farside crater to take readings, Jason and the others try to determine the origin of the bizarre Daedalus construction—but shortly after it lands among the eerie gossamer structure, the probe disintegrates. The staff frantically tries to find out the reason—there's no radiation, no detectable energy surge that would destroy the probe.

An infrared flyover of the Daedalus crater shows a "hot zone" in a circle about three kilometers in diameter surrounding the construction. Jason arranges for a sample-return mission using surface-penetrator geology probes. A contained sample is whisked off to Sim-Mars, an isolated lab on the far side of their crater.

During remote analysis of this lunar regolith sample, they discover the culprit—alien nanotechnology machines,

tiny self-replicating engines a billionth of a centimeter across. The Daedalus site is crawling with them, like a swarm of microscopic ants building an enormous construction, an atom at a time.

Meanwhile, back on Earth, **Celeste McConnell**, director of the United Space Agency in Washington, DC, is also trying to get some answers. Celeste is forty-seven, trim, extremely sharp, and a good public figure. As an astronaut seven years ago, she single-handedly rescued most of the crew members on the space station Grissom when a satellite impact breached the habitat modules, and has been a national hero since. The disaster killed her husband.

At the moment, she is working with Air Force General **Simon Pritchard**. As Celeste and Pritchard watch the remote analysis on the Moon, seeing the discovery of the alien nanomachines, Celeste promises Jason that she will send up an expert to help him study the infestation.

Celeste contacts the Nanotechnology Isolation Laboratory (NIL), which has been set up in the wastelands of Antarctica to allow researchers to perform risky tests with prototype human-developed nanotechnology machines. The NIL is staffed by the meticulous and well-respected old researcher, **Jordan Parvu**, and his assistant, **Erika Trace**. Erika is young and attractive, and a talented researcher in her own right, but Parvu thinks she is too buried in her work.

Celeste McConnell explains what has been discovered at Daedalus crater and asks Parvu to help them out with his expertise. Instead, Parvu delegates Erika to go. He thinks the alien

nanomachine infestation is a perfect challenge for her. Erika grudgingly agrees to go. Her next stop will be the Moon

*On her way up to the moonbase, Erika stops over at the orbital waystation, Collins. Along the way, she meets **Bryan Zimmerman**, or “Bryan Zed,” the regular shuttle pilot, who is very straitlaced and stiff, the type to say “sir” to everyone and **Bernard Chu**, head of the Collins station. A short time before, Chu had been unexpectedly replaced in his duties by the architect Jason Dvorak and he never quite understands the reason for Celeste McConnell’s decision. Chu is one of the other survivors of the Grissom disaster, rescued by Celeste’s heroics seven years earlier. Erika spends a brief time at the Collins, then is shuttled down to the moonbase.*

Meanwhile, on Earth, General Pritchard meets Celeste at a crab house for dinner. They are both dressed in casual, nondescript clothes. Pritchard wants to talk with her. He feels like an anachronism—his chosen profession is to be in the military, but with world peace for many decades and the solid cooperation of the United Nations to put pressure on any country that gets out of line, there isn’t much use for people like him anymore. When the alien nanotech threat appears, Pritchard believes that this “outside enemy” possibility would be a terrific chance for him to gain prestige and to make the military important again.

Celeste recalls how she rescued all the people in the Grissom space station disaster, how she had crammed them all into a small habitation module, sedated

everyone to keep their oxygen consumption low, and then waited for a rescue shuttle to arrive. What she doesn’t tell anyone, though, is that she had had a vivid nightmare the sleep-period before, something that she feels has warned her of the disaster. Several times in her life, she has had these “prescient” dreams, and though she is embarrassed to say anything about them, she believes them in her gut. She has had numerous uneasy dreams of late, and she believes it has something to do with the alien nanotech presence on the Moon.

On the Moon, once introduced to Jason Dvorak and the Columbus crew, Erika moves off to the isolated Sim-Mars lab and buries herself in her work. She begins to glean information about the alien machines. Her analysis reveals several different “species” of nanomachines, each having a different purpose—Assemblers, Disassemblers, Controllers, Quality-Checkers, Reprogrammers, and one type of nanomachine that is different from all the others, but she can’t determine exactly what it does; it seems not to have any type of assignment.

Needing someone to brainstorm with, Erika contacts her old mentor Parvu at the NIL. The two of them exchange ideas about the alien nanotech assemblers. Together, they speculate that the Assemblers originated from an alien civilization, hindered by the impossibility of faster-than-light travel, but yet still willing to visit other stars. The aliens could accelerate the tiny self-replicating nanotech machines nearly to the speed of light in a “shotgun” approach to nearby star systems. Once they encounter a planet, the prepro-

grammed machines could then start building things, such as the giant construction on the farside. As a transmitting station? For a ready-made base when the aliens' own slow ships arrive? As a prelude to invasion? Erika and Parvu have no way of knowing.

At the moonbase itself, Jason studies the growing alien construction. He compares photos taken over weeks and sees the gradual change, gathering some sort of idea of how the artifact is taking shape. He runs CAD/CAM simulations, trying to determine what it will be. He compares the stuff to some of his prize-winning architecture on Earth, even to his own homes. He tries to communicate with his wife, but the conversation is filled with friction. The cracks in their marriage are really beginning to show, and she has already filed for divorce.

Finally, when Erika believes she has learned everything she can about the Assemblers, she is homesick and wants to come home for a respite, to gather up new equipment, and to hand-pick some assistants. All of the Disassemblers in her samples have disappeared and she cannot figure out where they have gone. Meanwhile, the construction at Daedalus crater continues to assemble itself according to the alien blueprint carried by the nanomachines.

Parvu himself pulls strings to get Erika released from her duties. She gets on a return shuttle to go back to Earth, but is forced to spend a few days on the Collins until the next shuttle runs home. While she is waiting, Bernard Chu performs a routine blood test on her to check for bodily deterioration. Hours later, he calls her into the medical mod-

ule with a terrified expression on his face. Chu makes Erika look into a microscope and she sees swarms of alien nanomachines swimming around in the blood sample. Chu tells her that the nanomachines are not just in her blood, but his own and probably in everybody on the Collins. The entire station has been infested!

PART III

CHAPTER 14

Washington, D.C.

Celeste McConnell woke from nightmares to the insistent beeping of the phone link. She snapped away from sleep and rolled half out of bed. As she fumbled for the set, she saw it was the Stu-5—her secure phone.

She marshaled her thoughts, pulling her attention back from grogginess. Bad dreams had already warned her how important this call must be. A lot depended on how sharp-minded she could be.

Her two dogs, Chuck and Yeager—a black lab and a German shepherd—got up from the foot of the bed, growling, ready to defend her against any intruder. She shushed them as she turned on the “video receive only” channel of the phone link; there would be no pictures this night.

She felt a dreaded eagerness to find out what it was, what the nightmares had warned her about. Then at least she could stop wondering, though she would not know what to do about it.

Celeste finger-combed dark hair out of her eyes. “Hello?”

“Celeste?” Bernard Chu’s face appeared. The link was patched in from the Collins.

“Bernard! What are you calling

for?"

She remembered watching him frantically scrambling into the *Grissom's* Module 4 airlock, knowing their time was running out, knowing the station would be destroyed soon. Celeste still sent Chu's son, Shelby, a birthday card every year.

"Celeste, we have some big trouble here. We've got only five minutes before this call will arouse suspicion. I'm patching in over a private link—I commandeered one of my crewmembers' regularly scheduled calls home so that no one would think anything's out of the ordinary. We've got to do something."

She sat up now, naked on the bed, letting the sheets fall away from her. "OK, Bernard. Talk to me. I'm listening."

He wet his lips. "We've . . . we've been contaminated. Alien nanomachines!" Chu's voice twisted as if he were about to burst into panic, but he kept it under control. His expression hardened. She saw a man much older than the one she had rescued on the *Grissom*.

"Slow down, Bernard. What happened?"

"We brought that nanotech researcher back up from Columbus—Erika Trace. We did a routine blood test, as always with people passing back and forth. Celeste—she's got those alien nanothings in her blood. They've infected her . . . and they are in my blood, too! By now they've probably spread to all of us."

Celeste felt blocks of ice falling into her stomach. *The dreams had been right.* "Have you checked anybody else?"

"We just found out ten minutes ago. Erika Trace confirms it. I've ordered blood tests for everybody, including Bryan Zimmerman. I've got to keep fourteen people under control here. The *Rising Sun* is supposed to dock in half an hour, but I told them we were having difficulties and would have to postpone."

She saw Chu's hands squeeze together and his eyes close for a second, as if collecting his own thoughts, his terror, his anger.

Celeste's thoughts raced forward. *How had Erika Trace been infected?* She had double-checked the young woman's isolation and sterilization precautions herself. Jordan Parvu, Maurice Taylor, and Maia Compton-Reasor had all agreed that they were more than adequate. But somehow the alien nanomachines had broken through.

Celeste thought of the images of Waite, Lasserman, and Snow, as the *Daedalus* nanomachines destroyed them. But why hadn't they disassembled Erika Trace if they were inside her body?

Scowling, Celeste realized she couldn't trust anything the researchers did now. How could they be so cocky to think they could set up a defense impenetrable to alien technology, a technology sophisticated enough to fabricate nanomachines in the first place? Such a civilization could easily thwart any barrier scientists like Erika Trace might set against it.

What would happen if the infestation got to Earth? What if it spread from the Moon—like a plague?

"What should we do?" Chu insisted, breaking her train of thought. "I wish

I could see your face and talk to you directly.”

She glanced down at her naked breasts and her thighs, now sparkling with a thin sweat. The illumination seeping through the blinds lit them with a dim gray-blue sheen. Items of clothing lay scattered on the floor: glistening monoweave panty hose, a rumpled dress uniform. “Not now, Bernard.”

She waited, thinking. On the screen, Chu fidgeted. “Why didn’t Dvorak think to check Erika before letting her board the shuttle? If I had been moon-base commander—”

Silence. Celeste watched him swallow and sit up straighter. She softened her voice. “I don’t quite know what to do. Give me an hour to think about it. Don’t let anybody leave *Collins* station. Tell the *Rising Sun* that the delay is indefinite and find out how long they can orbit L-1 before they have to return to LEO.

“And finish taking blood tests. I must know the extent of this contamination, how far it has spread. I’ll call you back as soon as I have more information. Prepare yourself—we may have to take some drastic measures.”

On the screen, Chu nodded reluctantly. Celeste needed some time without him listening, to think and to discuss the possibilities out of earshot. “Thanks, Bernard. Keep me informed if anything else happens. I will speak to you soon.” She switched off. Her hands were trembling. The dogs whimpered, demanding attention.

Beside her, Major General Simon Pritchard sat up silently in bed. The wiry hairs on his chest looked like metal in the pale light. His eyes were wide,

blinking in astonishment. “Oh my God!” he said.

Celeste turned to him. “I was afraid something like this would happen.” She couldn’t tell him about the dreams. She could not risk having him lose his trust in her now.

Pritchard’s face looked boyish. Had it been only a few hours ago that they had been locked together, his arms around her, her legs around him . . . laughing, moving with him, giggling when the two dogs leaped onto the bed, practically causing the box springs to break? Celeste and Simon had drifted off to sleep, contented—but then the nightmares had come to stalk her.

She had been having a lot of bad dreams lately; what frightened her most was that she did not know how to interpret them. Not this time. She could not determine what the dreams were warning her of, but she knew that something terrible must be coming.

It had always happened like this. . . .

Her first “premonition” had been when she was eight years old, living in Quebec. Waking up, she felt as if she were suffocating; everything was dark and murky, and smelled of wet rot. She was drowning! Mud filled her lungs.

The next day, when her ten-year-old brother Christian wanted to go swimming in a nearby quarry, Celeste was terrified and refused to go with him. That afternoon, Christian himself had drowned. The dream-warning had not been for her own sake, but for her brother. She had not bothered to warn him. She had not interpreted the dream correctly.

The next time occurred years later when she was in college. A friend of

hers. Peter, had come to visit from upstate. He had stayed late. The weather turned drizzly and foggy, then cold, making for treacherous driving. The night before, Celeste had dreamed of cold, of loss of control, of breaking glass. When Peter turned to leave, she suddenly realized that the dream must have been warning her about him. Uncertain, she tried to get him to stay, but he begged off. She couldn't think of any good reason to give him.

Peter died in a car accident that night.

She was sure she could have saved him, but this clashed with the rational part of her mind. After all, she had a science background, believed in cause and effect, not ESP and pseudoscience. But were the drowning and the car accident dreams just a coincidence? Somehow she couldn't believe that.

And what about the *Grissom*?

Many lives on Earth, the Moon, and the *Collins* now depended on whether she could understand those nightmares again. And with Bernard Chu's call, she knew exactly what the nightmares had been preparing her for. Unfortunately, they suggested no solutions.

We can't let those alien automata reach Earth, Pritchard said. "Even if it means neutralizing the *Collins*. You see what the things are doing to the Earside crater. What if something like that showed up in the middle of New York City? The three people who first discovered it are all dead. How long is it going to be before the nanomachines take apart Trace and anyone else who's contaminated?"

Celeste drew in a breath. "I agree, though it'll be hard on us. We're going to take a lot of flak - but we can get

through it." She raised her eyebrows and met his gaze. "It may soon be time to bring your involvement out into the open. We need a strong general, not just a compassionate space agency director."

Pritchard pushed out of bed. Both big dogs jumped to him. Yeager reached up and pawed the general's chest; Pritchard distractedly eased him down to the floor and patted his head.

Celeste knew what had to be done. She said it out loud, to get it into the open. "We're going to have to quarantine the *Collins* station, and the whole Moon—as a first step."

Pritchard nodded as he looked for his uniform and picked up the shirt he had carelessly draped over her chair the night before. His mouth was a grim line. "No one there is ever going to be able to come home again."

CHAPTER 15

Collins Transfer Station, L-1

Strapped to the chair in the *Collins* observation chamber, Bernard Chu tried to control his breathing. Visible through the thick window on his left, the Earth occupied a good part of the starry sky. Opposite that, the Moon hung stark and unchanging, as if mocking him for having gone back to live in space. He had thought himself safe at L-1.

Directly in front of him the image of Celeste McConnell seemed frozen in the flatscreen. Celeste had not been able to offer him any convenient answers, though at least she was transmitting video now. He wanted to look into her eyes as she told him the bad news.

"Bernard—we all knew there would be risks," she said. "That's why we

sent only one researcher to Sim-Mars and kept the rest back here on Earth. I didn't want to take the chance that somebody would get exposed."

Chu tried to mask his frown. "Well, somebody did. And now we all are."

Celeste's face stared back at him, as she waited to receive the rest of his words. The two-second light delay made the conversation maddening. Every time Chu interrupted to ask her a question, the image would continue to speak, only to stop abruptly and glare foolishly back at him.

"Actually, Bernard, we don't know what would happen if the infestation reached Earth. The nanomachines should have reacted in your bodies by now, taking you all apart."

"Don't you think every one of us is just sitting here waiting for that to happen?" He couldn't keep from being angry at Celeste, though he knew it wasn't fair—she had saved him from the *Grissom* disaster years before, and he had always counted on her to give some kind of forewarning before another tragedy could strike. This time she had let him down.

The last time anyone had worried about an extraterrestrial virus was during the first *Apollo* Moon landings, and even then the precautions they took were a joke. Chu thought of how they had allowed the astronauts to be exposed to the atmosphere before locking them up in quarantine! He knew they had to do it correctly this time, and it was his responsibility not to let the nano-infestation spread further. He had a good guess what would occur if those machines got loose on Earth.

"—and Erika Trace must have been

infected at least a full day before any of you. Yet, you say she has shown no signs of any adverse reaction." Celeste plowed through the conversation, unmindful of Chu's interruption. When she stopped, the delay allowed him too much time to think, to feel sorry for himself.

"It's only a matter of time before somebody gets disassembled. We're all watching each other to see who's the first to turn into a blob of . . . whatever."

Celeste came back gently. "Bernard, I'll give you all the help I can from here, but I'm not sure what to do."

"I'm sure as hell not going to sit here and wait! What's happened to you, Celeste? You never resigned yourself to waiting for the end before! What would have happened if you'd done that on the *Grissom*? Where did this bureaucratic mindset of yours come from?"

Celeste's unchanging face finally sagged. She kept staring, her face grim. Chu watched her for ten heartbeats before he realized that she wasn't going to speak again, that she was waiting for him to suggest something better.

"These alien nanotech machines—" He jabbed at his chest. "—could take us apart in a few seconds if they wanted to. At least let us do something useful, dammit. What else have we got to lose?"

"Specifics, Bernard. What do you want to do?"

Chu settled down and got a grip on his emotions. He felt like a man dying of lung cancer who was about to volunteer to smoke two packs a day.

"The entire moonbase is infected too, thanks to Typhoid Mary. Dvorak

has confirmed that. So, it doesn't matter if we come into contact with them. I propose that we abandon the *Collins* and go down to Columbus. We can load up in the LTV and head for the Moon before anything happens."

"Convince me. What advantage is there?"

Chu shrugged. "They've got more resources down there. You just hauled the biostatistics equipment up here when you transferred my command. I'm a biochemist—maybe I can do some work on this, too."

"What do you propose doing differently?" Celeste's questions seemed to be pro forma, as if she wanted to see if his answers matched her own ideas.

"First off, I'd start taking care of things Dvorak should have done a long time ago. This is the perfect time to send a scouting party out to Daedalus crater, explore the artifact. Since everyone is infected, why should we be afraid of the nanomachines now?"

"You'll be disassembled if you do that." Her voice sounded cold.

"We should have been disassembled hours ago! Something has happened, a mutation maybe, and we need to take advantage of it! Our death sentence is already signed."

Celeste pondered this for some moments, but Chu could not tell what she was thinking, could not read her body language. Her voice came as a near whisper transmitted across cislunar space. "What about the rest of the *Collins* crew? Do they agree? Are all fourteen of them willing to go along with this?"

Chu thought of the two astronomers and one tech locked up and sedated in

the loading pod bay, how they had broken down and started raving when told of their infection.

He also thought of Bryan Zimmerman, who still did not know of their situation, though he too was infected. Chu had decided that, with so much riding on the pilot shuttling everyone down to the surface, it was best not to tell him yet.

Chu whispered, "Yes, everyone agrees—we need to expedite leaving the *Collins*."

Celeste glanced down at her watch. "We can't postpone the *Rising Sun* longer than seven hours before they have to abort and return to Earth orbit. Can you leave your station before then?"

"Of course." Chu felt confident in that much. He had checked already in the LTV specs; if everyone took only minimal items with them, the lunar transfer vehicle was rated to carry the full complement down to the lunar surface, though Bryan Zed might have a tough time piloting the heavy craft. And Chu wanted to bring as much of his biostatistics equipment as he could.

"Very well, now listen to me carefully." Celeste's voice became hard. "Once everyone has departed, we will remotely initiate the station shutdown sequence."

Chu frowned. *Shutdown sequence?* "That doesn't sound familiar. I was supposed to have been fully briefed before I took over command up here—"

Celeste waved a hand. "General Simon Pritchard is working with me to oversee a new instruction uplink to your onboard computers. We're writing the code as we speak."

"But what does it do? What's going to happen to my station?"

"Once we get you to the Moon, the uplink instructions will sterilize the *Collins*. No one—including that Japanese tug or any hotshot salvage artists—can be allowed access to the L-1 staging area anymore. Any contact could bring the infestation down to Earth. Do you agree?"

Bernard found a lump growing in his throat, but he couldn't swallow it away. "So what exactly is going to happen?"

"The instructions will cause your power plant's shielding to open: the reactor will then run up to maximum. This will irradiate the entire waystation and kill any of the nanotech machines that remain." She paused. "We hope."

Chu pushed back against the char netting, then nodded to himself as the words sank in. That would make the L-1 station unusable for years due to primary and induced radioactivity, not to mention all the damage it would do to sensitive diagnostic equipment. Without the L-1 rendezvous station, returning to Earth would be more difficult—if Earth ever decided to lift the quarantine.

A thought raced through his mind: *Did Celeste already know that we'd vacate the station . . . or did she plan to shut it down with us still onboard?*

He forced a frightened smile. Maybe the station would be an orbiting monument to their sacrifice, just like the proposed *Grissom* memorial that kept troubling Celeste all these years. At last the *Collins* would live up to its namesake, keeping vigil alone in orbit while everything else happened on the Moon.

If any of them survived the nanotech

infestation.

That was their first big problem.

Bryan Zimmerman kept his thoughts to himself as the last of the *Collins* crew loaded the Lunar Transfer Vehicle. *Seventeen people in a space for ten*, he thought, *not including all the equipment Chu had stuffed into the cargo bay*. Nobody would give him any details about this "emergency temporary evacuation," but they had kept him on the *Collins* for a full day and a half after delivering Erika Trace. He was already running behind schedule.

The LTV was overdesigned as it was—the specs allowed for a 50 percent increase in passenger weight, and he had carried twice that amount in supplies without breaking into a sweat.

But supplies weren't on the verge of panic, as were at least half the passengers here. He never understood why others couldn't keep their cool. He always did.

As Zimmerman punched up the outside aft view from the lunar shuttle, he saw the *Collins* grow smaller in the viewscreen. Evacuating the way station for the Moon without even leaving a skeleton crew behind seemed really crazy—but orders were orders. He had seen Director McConnell's authentication himself.

Zimmerman didn't question too many things. Management types operated with a different logic sequence than anyone else. He had seen perfectly normal people promoted to positions of authority and instantly become either phenomenally stupid or incredibly callous administrators. Luckily, he had no aspirations to become a manager himself.

The astronaut program was the perfect job in the perfect place for him—he had complete control of his own vessel, and for the most part people left him alone. It gave him time to think, to lose himself in the sea of stars. Gloria understood.

He stole a glance at Erika Trace as she settled in behind him. She looked really frightened now, withdrawn, not as pretty as she had appeared during the first trip to the Moon. But the weightlessness still caused her breasts to swell out more than they should have. Before he punched the orbital-transfer rockets, he sighed.

Erika watched the *Collins* recede as they moved away from her stepping-stone to home. Nobody was ever going to go back. Not until they found a sure-fire cure to the nanocritter infestation.

We're probably all going to die soon, she thought. Yet most of the people were taking it so coolly . . . until it struck her that this was just exactly what the astronauts had been selected for in the first place: why the initial and follow-on screening had been so rigorous. She was the only one who had been rushed through a condensed version of the training.

Bryan Zimmerman seemed particularly calm about the evacuation—but then, he never got excited about anything. The pilot ran over his checklist, unconcerned. Cool customer or cold fish? She couldn't decide which comparison fit him the best.

Erika looked up. All the passengers kept to themselves, their heads down, just looking toward the viewscreen, watching the *Collins* drop away behind

them as the pock-marked surface of the Moon rose up on the other side.

She lifted her own hand. Opening and closing her fist, she studied her fingers. She felt no different, but inside she knew she was swarming with nanomachines. *How soon—when will they disassemble me? Why haven't I died already?* The thought of an alien invasion inside her body made her feel violated.

A human voice, transmitted from Earth, came over the radio. "We have you five hundred kilometers away, Zed."

A synthesized voice broke in. "*Collins* reactor doors are opening."

Erika frowned, looked at the video-screen.

Moments passed, and again the synthesized voice spoke. "The station has been flooded for ninety seconds. Approaching critical temperature."

A pause, then. "Detonation sequence initiated."

"Detonation!" Bernard Chu burst out, sitting up against his acceleration restraints. "What detonation? How?"

Zimmerman's face held an expression of surprise, but he merely grunted his reply. "Please confirm last transmission. Detonation sequence?"

"Confirmed."

"I never agreed to this!" Chu cried.

Erika sat blinking in surprise, unable to believe any of this was happening. The other *Collins* refugees began to jabber among themselves.

"Please specify detonation—" the pilot started to say, but the waystation suddenly grew bright on-screen, overwhelming the stereochip's brightness monitor. The superheated reactor breached its containment and ignited all

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the fuel tanks. Rainbow colors danced on the viewscreen in silence, in the non-nuclear explosion.

An instant later Erika saw nothing but the black blanket of space filled with stars and twinkling bits of molten debris. Millions of superheated pieces of metal flew radially out from L-1, all that remained of the *Collins*.

Erika prayed that the radiation burst from the nuclear reactor had killed all the nanocritters left on board—and not hurled them through space toward other targets.

CHAPTER 16

Moonbase Columbus

Jason Dvorak watched the last evacuee from the *Collins* struggle through the moonbase airlock. Though the lunar gravity was only one-sixth of Earth normal, it seemed overpowering to the crewmembers who had spent the last four months in zero-g. Normally all personnel would have been gradually acclimated for a return to a gravity environment, but the nanotech infestation had not allowed any time for that.

Now, in the Columbus receiving area, all seventeen evacuees cycled through the electrostatic dust-suppression unit as they entered the base. Lunar dust hung in the air, and the filtration system couldn't cleanse the receiving complex fast enough. Everyone began coughing as soon as their helmets came off. As one of the first to be processed, Bernard Chu stood silently beside Jason like a conquering hero returning to reclaim the land that was rightfully his.

But the matter of Erika Trace burned foremost in Jason's mind. The sandy-haired young woman had seemed to

light up Columbus when she had first appeared . . . what, two weeks ago? She was so fresh, so nervous, so out of place among the other crewmembers. Her youth and naiveté had reminded everyone of normal life back on Earth. Something about Erika had hinted at the tourists and adventure seekers that were to come when the moonbase became a full-fledged outpost. Her attitude was a welcome change from the matter-of-fact professionalism that permeated the colony.

But this fresh-faced woman had brought the terrible nanotech infestation right into their homes. Through her incompetence, she had cut them off from any possibility of returning to Earth.

They would probably all be dead in a few days, because of her mistake. Jason would never again see his children. He would never learn exactly what the Dædalus construction was meant to represent. He felt like a jackrabbit on the road at night, frozen by approaching headlights.

How many centuries had it taken humans to reach the Moon? To establish a precarious toehold on a bit of lunar rock that still demanded the utmost of combined technology for simple survival? Yet the whole effort—billions of dollars, trillions of rubles and yen—was now wasted because of an alien infection caused by what must have been a moment of carelessness on the part of this young woman.

Watching Erika as she struggled out of her spacesuit in the receiving dock, Jason felt anger well up inside. He had liked her a lot, but now his jaw involuntarily tightened. She had ruined everything for them.

But yet—

What did they have to gain by touching Erika Trace?

Jason knew deep down that it was not her fault. She hadn't done anything not demanded of her by Director McConnell. Erika had been in the wrong place at the wrong time. Erika had never wanted to come up in the first place. But Jason couldn't bring himself to transfer the blame completely, not now. He had to have a scapegoat, someone that he could shake a finger at, didn't he? For a disaster of this magnitude!

Everyone else felt the same way, from the grumbling he had heard in the tunnels. He wondered who would get Erika first—the alien nanomachines or the angry moonbase inhabitants.

The last evacuee stumbled into the airlock. After removing her helmet, the woman bent over and started coughing from the floating dust. Newellen squeezed through the lock behind her.

The dust shield around Newellen's mouth looked like a button on an oversized clown, but at least it kept him from coughing like the others. When he spoke to Jason, the filter muffled his voice. "Have you heard the word from Earth? We didn't catch the latest on the riots."

"Riots?" Jason lifted an eyebrow. *With all that was going on, who would think to listen in on any of the Earth channels.* "We've kept in contact with only the Agency the last few days, and they didn't mention anything like that."

Newellen rolled his eyes. "Surprise, surprise."

"What is going on, Big Daddy?" asked Chu. Jason wondered if McConnell

would give Chu his command back . . . and if he himself really cared.

Newellen rubbed his hands along his coveralls, then snorted as none of the dust went away. He looked at Jason, then Chu. "Well, since nothing's left of the *Collins*, I trained the directional antenna back to Earth, and picked up the newsnet broadcasts relayed up to geosynchronous sats. It was a little weak, but I'm sure we could pick up the sidelobes here—"

"The news, Big Daddy," said Jason in exasperation. "What's going on?"

"You mean the riots?"

"Yes, Lon."

"Why didn't you ask? Earth seems to be going absolutely apeshit—marches, riots, protests, all that type of thing."

Jason turned to Chu. "Did you hear anything about this before you abandoned the *Collins*?"

Chu merely shrugged. "We had an open line to the Space Agency, but they indicated nothing for us to worry about. Of course, they didn't bother to consult me about blowing up my station either. 'We can never afford to have anyone set foot on the *Collins* again,' Celeste says. She made damn sure of that!"

Jason looked around. The evacuees had been ushered off to the infirmary for checkups and monitoring. Jason didn't know how they were going to fit seventeen more people into the limited quarters; crowding would make tensions rise even higher, but there were going to be some mighty close friends before this was over. If anybody survived.

Chu nodded in the direction of the control center. His face looked flat and tight, his skin stretched like a drumhead

over his cheekbones. "Let us find out what is going on. If Celeste is feeling a great deal of pressure, she may decide to do something . . . drastic."

As they started for the control center Chu held out a hand to steady himself against the wall, but once he got his step he seemed to be all right. They passed through two airlocks and a series of interconnecting tunnels through the buried modules to reach the domed control center. The tunnels were constructed of inflatable foil, made rigid by an interlocking agent.

Once in the control center, Jason called to Cyndi Salito sitting at her duty station. "Anything unusual over the link to the Agency?"

"Nothing out of the ordinary," she said. Salito had been scheduled to go home on the next rotation of crewmembers to Earth; now she would be stranded on Columbus with the rest of them.

"No news flashes, public unrest?"

"Should there be?"

Chu stepped up. "Have you been monitoring anything other than the Agency channels?"

"Just listening in on Agency Select." The semi-official channel carried news items, human interest stories, and some of the more popular shows that highlighted the United Space Agency's efforts. Jason knew that the crewmen didn't have the time or inclination to call up and pay for commercial video, and the Select channel normally did an outstanding job of distilling what was important out of the hundreds of drivel newsnets. It was generally hard to pick up the commercial nets anyway with sufficient resolution to make them

worth watching.

"I suggest we try some other frequency. Tune in one of the commercial channels," Chu said to Salito.

Jason felt embarrassed to be caught so much off guard in front of his predecessor. He had never thought the Select newsnets would turn out to be a one-way propaganda filter.

Seconds later the talking head of one of the commercial networks appeared in a cube, worms of purple and gray static lacing through his 3-D image. "Locked on," said Newellen. Standing next to Salito's station, he munched on a sandwich, probably retrieved from a hiding place in the control center.

"—since the startling video transmission of astronauts dissolving on the Far-side of the Moon and the discovery of an enormous alien construction being built there. The United Space Agency still vehemently denies that the phenomenon has spread to anywhere else on the lunar surface."

The announcer's head faded out to show footage from one of the flyovers of the growing Daedalus construction, looking like a gigantic diamond water lily sprawling across the crater floor.

"We switch now to Julia Falbring, our science correspondent, who is with Dr. Maia Compton-Reasor, a prominent researcher in nanotechnology at Stanford University in California. Julia?"

"Thank you, Tom." The image resolved to show a curvaceous blond. Besides the fact that she wore a minimum of clothing, Julia Falbring's skin, hair, and even voice were so perfect Jason thought she must be a computer-generated sim-person, living only in some cyberworld.

"Here at Stanford, Dr. Compton-Reasor heads a group of researchers at the cutting edge of technology." A squat black woman appeared beside her; red-rimmed glasses slid down her nose.

Jason found his mind wandering as the holotank filled with an artist's conception of a tiny molecular construct. He looked around. The control center was crowded with more than the normal number of people. Most of the *Collins* crew would still be checking through the infirmary.

Erika was not among those who had come to the control center, though she would not have been much affected by the change in gravity. He wondered if she would hide herself away at the Sim-Mars lab again, to keep working with the nanomachine specimens. Jason considered calling her to his office, but thought better of it. If *he* had been responsible for infecting the crew, he'd want to hide as well. Jason turned back to the holotank and the commercial newscaster.

"—and with that in mind, I think we all have something to ponder, Tom."

"Thank you, Julia." The newscaster swung around in his chair as a corner camera took the shot from another angle. "And finally, we have live in our studio Major General Simon Pritchard, special assistant to the director of the United Space Agency. General?"

"Thank you, Tom." The view drew back to encompass the features of General Pritchard. He sat back in his seat, relaxed, with one leg crossed over the other. His Air Force uniform looked immaculate. It was plain, blue, and not overladen with the medals or emblems so popular with the other military ser-

vices. Jason remembered Pritchard as the man who had been with Director McConnell when Columbus sent the first telepresence explorer to Daedalus.

"General, just how seriously is the Agency taking this threat of alien technology? We've just seen through our special effects studios how an entire planet might be devoured if nanotechnology is allowed to run rampant. Is there anything we can do?"

"Well, first of all, Tom, we're not sure that this is *alien* nanotechnology. That's all conjecture at this point, though the Daedalus artifact is indeed being built by microscopic machines.

"We still have no idea what the big construction will turn out to be or when it will be finished. Because of the extremely hazardous environment surrounding the site, we cannot even send remote vehicles to explore it directly. We're working with very limited information." Pritchard folded his hands in his lap.

"We're trying to cover all our bases. An eminent team of life science specialists manning the Lagrange waystation *Collins* has been shipped to the Moon, to assist in the examination of this phenomenon. They even recommended destroying the *Collins* so there would be absolutely no chance of infestation—"

"What?" interrupted Newellen in the control center. He looked around the room. Chu stood mute. Jason scowled at the screen.

"—in fact if this were a runaway nanotech threat, all the experts agree that the entire Moon would have disassembled days ago. So really the situation has been blown out of proportion. Granted that the unfortunate accident to

Trevor Waite and his companions was widely disseminated. some evidence suggests that all three of them merely had a case of massive micropuncture, perhaps from an anomalous meteor shower. And, yes, the destruction of the *Collins* was costly . . . but it shows how far our astronauts are willing to go to ensure Earth's safety."

"I can't believe it!" The Columbus control center filled with a storm of response.

"Quiet!" yelled Jason. "He's trying to build a cover story. Let's just see how the hell this turns out."

Newellen grumbled as he waved up the volume.

The newscaster nodded sagely. "But suppose this is something out of sci-fi—you know, what if the Andromeda strain were to really exist, an alien robot virus that could wipe out our world? What would we do then?"

Pritchard's face went stone cold. Even Jason thought he could feel a drop in the temperature. "That is why the United Space Agency appointed me as their military deputy, Tom. If anything ever arose that would harm the sovereignty of the United Space Agency's signatory countries, we are prepared to deal with it in the swiftest, most decisive manner. The old methods of using conventional procedures would simply not work against such an insidious threat. Thus, we are prepared to do all we can, if need be."

The video took a close-up of the general. Jason could see muscles working in Pritchard's jaw.

"Swiftest, most decisive manner?" the newscaster asked. "What precisely can we do to prevent this thing from

getting to Earth? After all, we've got a crew of what, thirty or so people on the Moon, including those from the *Collins*?"

Pritchard waited a beat before answering. "Let me make myself perfectly clear. There are many options that the military has in order to prevent the contamination of Earth. We may have to make some tough choices."

"Exactly what types of choices, General?"

"Let's hope it never comes to that," Pritchard said with an edge to his voice. "And you must remember that everyone on Moonbase Columbus is aware of the consequences and the risks they accepted when going up there. *We cannot risk contaminating Earth*—that is the paramount concern."

Newellen shouted over the buzz that started to rise around the control center. "What the hell is he talking about? Has he written us off, or what?"

"Switch back to Select," said Jason, quietly.

"What?"

"I said switch to Agency Select." Few grumbled when a second image slid into the cube, sharing space in the cube with Pritchard's interview. An old video of a space shuttle shot filled the cube. The hushed voice of the narrator described what an awesome task it was to be in space to stay.

"They're not even covering the news conference," Jason said.

Chu snorted. "They're interviewing McConnell's deputy about leaving us high and dry on the moonbase, and Select is showing reruns."

Jason thought for a moment before speaking. "Does that tell you how

much Director McConnell really cares about what happens to us up here?"

In his mind Jason saw an image of the abandoned *Collins* self-destructing in a silent fireball. "What does she have in mind for us?"

CHAPTER 17

Sim-Mars

Back at the Sim-Mars lab module, Erika felt as if she were the only sane person remaining on the Moon. There was really no need for her to continue her investigation in isolation; Columbus certainly had enough laboratory space, biochemistry equipment, experts in life sciences—including Bernard Chu—and plenty of other technicians to assist her.

But Erika didn't want their help as much as she wanted to be alone. She had to get away from all the angry glares. The people blamed her for releasing the samples, for infecting everyone on Columbus, just like Typhoid Mary.

She went over and over her procedures, trying to discover where she had slipped, where she had breached her own rigid experimental protocol. Even Parvu couldn't see what she had done wrong. But the nanocritters were so resourceful that they could have gotten through any barrier she tried to erect. She had been foolish to think otherwise.

So what were the nanocritters waiting for? Something must have changed inside of them. Did it have anything to do with the Disassemblers vanishing from the regolith samples? How had the nanocritters modified their programming to know not to disassemble people?

Nanocritters. Even her half-whimsi-

cal nickname for the microscopic robots didn't seem humorous anymore. Not when she had billions of them coursing through her bloodstream, waiting for some signal to destroy her. If indeed that was what they were waiting for.

Compton-Reasor's group at Stanford, Taylor's at MIT, Sommerveld in Belgium, and even Parvu had offered every assistance from afar. Some pondered the problem with computer models, others configured mock experiments. But simple suggestions were worth only so much, and working over the 240,000-mile telepresent link was far too cumbersome, even with slow test procedures.

Erika pulled back from the holographic monitor and stared at the nanomachines swimming through the sample of her blood. Small enough to assemble viruses, the nanocritters were not even noticed by normal human immune-response systems.

She rubbed her eyes and concentrated on the holotank display. She had to find some answers. Her fingers skimmed over the controls, programming the computerized scanner to run another analysis of the blood sample, this time sorting for any nanomachine not explicitly matching the known configurations of Assemblers, Quality Checkers, Reprogrammers, or Controllers.

The disappearance of the Disassemblers was the crux of the matter, she felt. They had vanished from the regolith samples contained in the Sim-Mars chamber, and they had not appeared in any of the infected blood samples, though all the other types of nanocritters had been passed on.

As far as Erika knew, the Disassem-

blers could be hiding, massing for an attack. And if that happened, there would be no warning. Everyone was infested with nanomachines from the inside out. Everyone on the Moon would dissolve in an instant. She couldn't imagine how it would feel—like being eaten alive by billions of hungry ants?

Erika activated the scanner, setting the computerized machinery in motion. The scanner initiated a shape-matching algorithm of the nanotech machines in Erika's blood against the stored templates. The microwaldoes and their imaging sensors traversed the drop of blood like a giant ocean liner plowing across a pond. On the holotank's screen, nanocritters were caught up in the microwaldoes' wake, swirled around in the turbulent flow.

She glanced at the backup telepresence units next to her. Identical to the sealed infection chamber at which she now worked, the three other units displayed similar statistics on their flat-screen panels. Each of the Earthbound teams was conducting separate and independent investigations, but no one had suggested what to do about the infestation. Because of the light delay in the feedback loop, their telepresent microwaldoes moved unsteadily though their samples.

Even as the millions upon millions of nanocritters were examined, cataloged, and discarded, Erika knew that it would take hours to completely analyze the sample. She pushed away from the station and stood, stretching.

She padded to the coffee machine at the back of the lab, and after pouring a cup, circled back to the holotanks. Tucking her legs underneath her in the

chair, she made herself comfortable and waved on the communications tank. "Jordan Parvu, please."

The screen blinked, waited for the signal and response from the NIL, then Parvu's face filled the holotank. It took a second, but the sleepiness in his eyes disappeared as he recognized Erika. "I hoped it was you, Erika! I was wondering if you had made any progress."

"No." She shook her head. "Still no luck." The light delay made Parvu's expression seem frozen in the tank.

Erika sipped at her coffee. "How are things going down there? I haven't heard how the rest of the world is taking this. And the Agency Select channel is worthless as far as critical information."

"I'm afraid I do not know much more than you. Remember, I am pretty isolated myself. But from what I have heard talking with my son and his wife, people aren't taking this too well. I hear there has been a resurgence in all the old threat-from-space films—*War of the Worlds*, *Alien*, *Earth vs. the Flying Saucers*. I have been far too busy trying to think of a way to help you. How do you yourself feel?"

Erika answered carefully. "I'm tired and scared, a little weak, but that can all be explained by my circumstances. No need to invoke some external agency. As far as I know, no one that's been infected has experienced any . . . changes."

"Perhaps the automata are working on something in your body that you do not know about. How would you know, for example, if they disassembled your appendix?"

"I had mine removed when I was

ten

Parvu waved at the air, then smiled. "Then how would you know if they rebuilt it? Anyway, that was just an example. He shrugged his narrow shoulders.

"I'm having another one of those microcameras sent over to Daedalus today. Still no progress on why the Disassemblers vanished from our samples. That's the key, I think. What if all the Disassemblers have stopped taking material apart and are now finishing up their construction?"

Parvu tapped his fingers together. "I have a different idea. Do you think it has anything to do with the presence of organic material?"

"You mean can the nanocritters tell if they're inside a living organism?"

Parvu placed a thin brown finger on his lips. "At this moment, my suspicion is that the automata can indeed determine the difference between organic and inorganic material. And they have instructions not to disassemble living substances."

Erika shook her head. "Even if that were true, they should have disassembled the skin of this lab, my spacesuit, all of our life-support equipment."

Parvu's answer came quietly after the two-second delay. "Perhaps they know to switch themselves off, or at least do nothing more than collect data and replicate themselves inside a living organism without causing damage."

Erika frowned at the implications. Just the problem of mass communication between the billions of nanocritters seemed too difficult to overcome. But she had to consider the possibility; had she been given a reprieve by the alien

minds that had programmed their scouts?

CHAPTER 18

Sim-Mars

Erika woke with a start. As she opened her eyes, she felt as if she were falling. She reached out to steady herself, and discovered that she was sliding off her chair in a dreamlike, low-gravity topple. Her stomach lurched as she suddenly knew that the disorientation, the buzzing in her head, the vertigo was all from the nanocritters inside her body. They had finally decided to take her apart. *She was dissolving!* She struggled until the black tatters of sleep finally cleared from her mind.

It took a second until everything came back to her. She was on the Moon, in the Sim-Mars lab module. She must have dozed off while keeping watch on the interminable experiments. They needed some drastic action to get rid of the infection, and it was up to her. And she didn't have the courage, or the imagination, to figure out what she needed to do.

Erika glanced around the lab, blinking away the blur from her exhaustion. In the center of the module, the steel column holding the sterilization apparatus ran straight up from the floor; the holotank was built into the cylinder to save space. Four isolation chambers of varying sizes were set symmetrically throughout the room. She had tests running in two of them, with tandem telepresence verification tests in their counterparts.

Ordinarily, she should have sterilized the Sim-Mars lab two hours ago and requested a new sample from the Far-

side crater. But it just didn't make sense to waste an important sample now. The nanomachines were already loose, contaminating everyone and everything on Columbus—what more access could they have? She just had to gamble now.

Especially if what Parvu had suggested was true. Had the Disassemblers really gone into a "fail-safe" mode because they had encountered a living organism? Had they mutated, perhaps, into something dormant . . . until something turned them on again? Some follow-up signal from the faceless aliens? And what other evidence did Parvu have, data he was reluctant to share with her?

Back at Columbus, Jason Dvorak continued to study the growing structure, attempting to second-guess what the nanocritters were building, hoping to find some clues to understand the purpose behind the aliens. By extension, that might provide some insight into how Erika could defeat the infestation in their own bodies. But so far, none of it had helped.

Fighting the stiffness and aches of a bad sleep, Erika picked up her cup of cold coffee from the control panel. Dumping it into the reclamation sink, she prepared a new cup from the dwindling supplies and studied the isolation tank experiments. Still nothing exciting, nothing helpful.

Inside Erika's body, her life was ticking away, dependent on microscopic machines. Even if the aliens had taken enormous precautions, with the sheer number of automata present, surely one of the robot memories would get zapped by a stray cosmic ray and "flip a bit," the electrical equivalent of a hiccup.

And if that just happened to switch off the fail-safe mode. . . .

Erika had to understand it before she could consider any solutions. She had to know what the Assemblers were doing in her bloodstream, besides multiplying. Were they gathering data—for later? The nanotech Controllers were running the show, giving their Assembler servants every instruction.

A thought came into her head. *If the Controllers can reprogram the nanocritters . . . if a cosmic ray might scramble their instructions . . . why can't I?* Because she didn't have the slightest idea where to start.

She mulled over the thought. Each nanocritter has a memory like that of an ancient supercomputer. Altogether, they were very clever, very sophisticated. They had the capacity, but did they have the flexibility, the intelligence to understand?

What if there was a way to reprogram the existing Assemblers, to direct them not to replicate themselves? The population of nanocritters would exist in steady state.

What if she took the next step? What if she managed to program Assemblers to seek out other Assemblers, destroy them, then shut themselves down when they could find no other prey?

A new and improved multi-purpose Assembler! Yes, that would be wonderful. But then it would really be a *Destroyer*, wouldn't it? It would cleanse her bloodstream, purge the entire moon-base of the nanotech infestation.

Erika grew excited at the prospect. The only problem was how to go about reprogramming the nanocritters. She had not learned the smallest detail about

the operating system resident in the sub-microscopic memory cube of each Assembler, nor in the larger controlling stations. Erika herself was no expert in machine languages, though she knew a little about basic programming.

Earth computers had become so intuitive and user-friendly that no one needed to know the nitty gritty details of code. You could tell the computer what you wanted, and it usually accomplished the task. You didn't have to dissect its circuitry to add a new program. And these nanocritters were vastly more complicated and sophisticated.

Erika stopped, flushed with excitement. She set her mouth, feeling as if she was back in grad school again and had stumbled onto the solution of her thesis problem. Except now, the stakes were much higher.

She almost had it. Her muscles were tense, cramping as she hunched over the holoscreen, working the microwaldo controls. She was afraid to move, afraid to do anything that might shatter the spell.

Reprogramming the Assemblers.

Instead of trying to induce an electronic, or an even more cumbersome chemical change, among the nanocritters, why couldn't she take advantage of their heuristic programming? If the Assemblers "learned" to adapt to their environment, why couldn't she modify that environment to produce the results she wanted?

First she had to scramble them, "reset" their rigid programming into something that might be amenable to modification. She had taken a large sample of the nanocritters and bombarded them

with radiation—neutrons, charged particles—enough to destroy many of them, and alter the rest. Leave them open to suggestion.

She would try to . . . *train* them. Modify their behavior. Teach them what to do. She couldn't think of any other way to describe it.

She had huge numbers of the nanomachines to work with. Surely some of them would turn out the way she wanted. If she provided the right stimuli, some of them might get the hint.

Erika flipped through her online archives, skimming over how B.F. Skinner had set the wheels of behaviorism into motion back at Harvard years ago. As part of their heuristic behavior, the Assemblers had shown a remarkable tendency to learn, so all she had to do now was shape their environment to get the intended response, nudge their behavior in the direction she wanted.

The intended response would be to switch the Assemblers into a "Destroyer" mode. But how to do it eluded her. What could she do to encourage them to kill each other?

A voice from the holotank jarred her out of her thoughts. "Dr. Trace?" A message window appeared in the holotank, overriding her background images. "Erika? This is Jason Dvorak."

"What?" She was surprised at the curttness of her response, but the irritation dug at her. *I almost had it!* As she turned to the holotank she pushed back her hair. She realized she must look haggard, a mess. "Yes, what is it?"

Dvorak was in a spacesuit, his helmet off. His image bounced as if he were riding in a vehicle. He looked apologetic. "Sorry if I disturbed you—"

"It's all right," she lied. "How can I help you?"

"I'm about ten minutes away from Sim-Mars. I've decided to come over and help you."

Ten minutes? Her instant reaction was that she didn't want him bothering her right now. She fought the urge to switch him off. Erika had no need for distractions. Now that she felt close to a solution, Dvorak thought it was tourist season. She frowned. But if he was offering to help, then she would put him to work.

"Thanks for the warning. Ten minutes." She smiled sweetly, turning on the Southern charm that made everyone think she was a bimbo. *Right.* "Will you need any help getting in?"

He gave the hint of a smile. "No. I know the way."

After Dvorak switched off, Erika caught a glimpse of her reflection on the metallic surface of the sterilization cylinder. *No use being completely uncivil,* she thought. For no other reason than common courtesy, she slipped to the bathroom cubicle. And after washing her face, she decided to brush her hair.

"Hand me that milli, please," she said to him, not looking over her shoulder. When he didn't respond, she said, "The milliwaldo glove, over there." Erika nodded to the set of gloves that hung by the experimental table.

"Sure." Dvorak stood in front of the gloves. They were lined up in descending sequence, color coded with embossed words: DECA, MILLI, MICRO. Remotely connected to the waldoes, each glove controlled any

movement of the tiny devices. Dvorak pulled a yellow glove and handed it to Erika.

"Thanks," she grunted. He genuinely seemed to want to help, to be supportive and offer whatever assistance he could give.

She used the glove to guide an array of milliwaldoes against each other, overlapping their splayed fingers to form an enclosed chamber. One by one she placed the milliwaldoes around the enclosure until she had formed a tiny cage only a millimeter in size. Closed, the claws of the milliwaldoes made bars too close-set for any of the nanocritters to push through. A high voltage, electrostatic charge along the surface would keep the nanomachines from disassembling the equipment itself.

Satisfied that her box was sealed and escape-proof, she zoomed the holotank view down by three orders of magnitude. The tiny cage now appeared to be an impenetrable wall.

Still wearing the milliwaldo glove to hold the cage in place, Erika used the microwaldo on her other hand to round up the Assemblers she had earlier bombarded with high energy radiation. They looked like a horde of bubbling gnats as she herded them into the cage, then pushed a grain of regolith in after them. Sealing the box with another milliwaldo, she locked the waldoes in place before leaning back with a sigh.

Dvorak stood next to her, fidgeting. After some moments had passed, he finally said, "So what next?"

Erika looked up. Dvorak waited, not pressing the issue. She had not explained her idea to him, though she had thought it would be obvious from her

actions. But then she realized that Jason Dvorak was an architect, not a microengineer. To someone not versed in research methods, Erika might have been performing some sort of witch-doctor rite.

Erika nodded to the holotank which, at this magnification, still showed the immense expanse of the nullwaldo as a cage for the nanocritters. "We can't come up with some sort of quick purge to get rid of all those nanocritters in our bodge. At least I can't think of anything. We need to find some other way of going about the problem. Come up with a new weapon."

Dvorak's forehead creased with concentration. "So why enclose these things in a box?"

Erika grinned. "These nanotech machines are not dumb. But they're not very smart either, not intuitive. They have a limited amount of intelligence, if you want to call it that, with a whole bunch of sophisticated programming. Look at the Daedalus construction, with one of the Controller substations just carry a complete blueprint of the whole structure! So, I'm hoping they're smart enough to take a hint, if I can make the hint clear to them."

"So what's the hint?"

Erika scrambled them with high-energy particles. Maybe that'll knock out some of their old programming and leave them open to suggestions. I'm trying to teach them a different type of behavior.

Erika poked a finger at the box made up of nullwaldoes. "Here's my rationale. We already know the Assemblers power themselves by using energy from breaking chemical bonds—but they

seem prohibited from using organic molecules. At least for now—that's why we haven't been gobbled up. But if they can't break down a few molecules every minute, they'll go dormant."

Dvorak nodded and smiled. But he obviously didn't get it.

"So, I've trapped a lot of those buggers inside my cage here. They can't get out because of the electrostatic fence I put up. I added a grain of regolith to keep them happy for the time being. But once that runs out, and since there's no organic material to cause them to switch off, they start getting hungry."

"So what next?"

"We sit back and wait."

"For what?"

Exasperated that Dvorak still didn't understand, Erika said, "Take an overpopulation of rats in a box and throw in a piece of cheese. If there's not enough cheese to go around, the rats learn a new behavior pattern—when they get hungry enough, they start eating each other."

Dvorak paced behind her chair, as if he were digesting the information. Now that he had shown a healthy interest in her work, she looked at him in a different light. Before, Dvorak had come across as a know-it-all, insisting that she get him some answers. But under the circumstances, with the sudden pressure and the relative newness of his command, and with her coming up to the moonbase demanding special treatment, Erika could understand his reactions.

He didn't look as old as she had first thought either. Without the thinning spot on the top of his head, his dark curly hair and narrow face gave him a boyish appearance. The persistent up-

turn of his lips made him appear on the verge of breaking into a smile. Even the faint lines around his dark eyes didn't seem threatening. . . .

Jason spoke softly. "So you're training some of these Assemblers to run amok?"

"Well, we can use them to attack the other Assemblers in the bloodstream. If Dr. Parvu's fail-safe theory is correct, they won't be able to do anything to the organic material in our bodies—they won't have any other source of energy, besides other Assemblers."

Jason snorted. "I never thought I'd be saved by cannibals."

Erika didn't mention the other possibility, the nagging fear that had almost made her stop the experiment entirely: She could just as well be training the nanocritters to devour organic material. She had to hope that the restriction was fundamental to their programming and could not be overridden so easily. Otherwise, the moonbase would be disassembled after all.

Tense, Erika trembled as she moved the milliwaldo. Under high magnification from the scanning optical microscopes, her motion made the cage door look like a giant wall grinding slowly to one side.

Seconds later, a flurry of small, dark shapes wiggled past her field of view, moving like bullets into the test solution and beyond the field of view. The rest of the cage was empty.

Jason's voice close behind her asked, "Well, did it work?"

Erika reached up to adjust the counter and ran a slow-motion replay in one of the holotank's cubes. "Watch."

The freed Assemblers sped out of the box, this time on a timescale a thousand times slower than what she had just observed. Something about them reminded her of a submicroscopic wolf pack. She counted only eleven of them—out of the thousands she had corralled.

"Did it work?" Jason asked, worried.

Erika flopped back in her chair and ran a hand through her hair. Her hand started trembling again. But this time she was grinning. "Yeah, I think so. In fact, I'm pretty sure."

Jason remained unconvinced. "You don't sound excited."

Erika cracked a smile. Suddenly, she remembered Jordan Parvu hauling out his stash of caviar and celebrating their success with the crude prototypes in the NIL nanocore. "This is all the excitement you get. What am I supposed to do, get up and dance?"

On impulse she staggered to her feet. She hadn't stood up for hours, and even in the relatively low gravity the blood rushed from her head, making her feel dizzy. "If you insist." She grabbed Jason, lifted his arms, and began a clumsy twirl around the lab.

Jason looked shocked, but after a beat he managed to take the lead in a pantomimed ballroom dance that brought Erika to the front of the lab without breaking anything. Once stopped, she held a hand to her mouth and giggled. Jason looked bewildered.

Erika pushed back her hair and put out a hand to steady herself. She noticed her drawl coming back and tried to restrain it. "Ever since I came up here you all thought I was some sort of wiz-

and called in to save the world. And now I think I just did!" She stopped, at a loss for words.

Jason nodded with a bemused look. "I think I understand. I went through something like that when I first got here too. I never planned on being put in command of the moonbase. I was just the subject. And now Chu's back."

Erika jumped when Jason placed a hand on her elbow. He steered her back to the holotank. "But we're not cured yet. What do we do next?"

Erika ignored that question as she sat back down. "Why did you come out here to Sim-Mars, anyway? Everyone else

is scared to death we're all going to die." Jason blushed for her. He looked into her eyes and fell silent for a moment. He started to answer, hesitated, then said, "I thought you'd need some help, that's all. Like you said, everything is riding on your shoulders, and I figured you might appreciate another back to carry the load."

"But you're still the moonbase commander. What about your own responsibilities?"

Jason smiled wanly. "Bernard Chu is doing very well, thank you. But that's beside the point right now. You need to save us." He scooted his own chair closer to hers.

Erika blinked. "All right, let me take some blood. I'll inject the, uh, 'nanocannibals' into the sample. We'll use that as our test."

Jason started rolling up the sleeve of his powder-blue jumpsuit. "I hope you take blood better than you dance!"

She gave the test half an hour longer

to run than she had originally intended. This allowed more time for complications to set in, and it permitted her to record a full report of her procedures creating the modified Destroyers.

She preferred her nickname of "nanocannibals," but with the other tag of "nanocritter," her peers on Earth would say she was being too flippant with a crucial problem. Prudence dictated that she follow at least some semblance of professional demeanor.

Jason peered over her shoulder as she prepared the solution of nanocannibals and displayed the results. "What's up?"

"Look for yourself. It worked. Every last one of those suckers is gone."

"You mean the nanomachines in my blood?"

"At least the ones in your blood sample. And the nanocannibals don't seem to have damaged any of the blood cells at all."

Jason beamed with relief, then frowned. "What about the last nanocannibal? They all ate each other, right? So the king of the mountain has to be left."

Erika thought for a moment. "Starved to death. Nothing else to eat, you know, and it's prohibited from breaking organic material. We hope."

Jason gestured toward the walls of the Sim-Mars lab. "I still don't understand why they didn't go after the non-organic stuff all around us."

"Why should they? Their behavior was modified to only go after other Destroyers, the only other 'food' they had. We weeded out all the other ones. The important thing is that it worked. Now I've got to test it on something that mat-

ters. We've got to see if it'll work in the human body."

"Don't we need to run some more tests first? Look for side effects, double check the procedure—"

Erika flipped her hair behind her ear and frowned at him. "Look, every one of us has a time bomb inside. What if the Controllers decide to circumvent the restriction on organic material? The Assemblers are still there—what if they decide to alter our DNA somehow? I'm not waiting around for that to happen, especially when I have something that might work."

"Point taken." Jason started to roll his sleeve back up again. "I've got nothing to lose. Let's get to it."

Erika shook her head as she eyed the hypodermic, now filled with a second generation of nanocannibals. The solution looked perfectly clear to her naked eye, but the liquid teemed with reprogrammed Destroyers, already devouring each other. "You're too important, Jason. You're the moonbase commander. I've already done everything I can."

"Don't be stupid. You can always try something different. Nobody else has your background. You can't give up."

Erika said. "I'm not giving up. I'm being practical."

As Jason took a step toward her, Erika considered warding him off with the filled hypodermic; but the thought nearly made her laugh. She thought of all those scenes from old plague movies, where the brilliant doctor comes up with a risky serum to cure the disease and decides to test it on himself first.

Before, Erika had always found those scenes ridiculous. But as Jason held out

his hand to her, she quickly jabbed her arm and squeezed the hypo. "Ouch!"

It wouldn't really matter if she hit an artery or just muscle tissue. The nanocritters were inside her body. She could just as well have smeared the nutrient solution on her skin.

She felt Jason's arms around her. "Sit down, you idiot." He helped her to her seat.

"At least I'm an academically trained idiot," she said. Sitting back, she felt suddenly woozy. "Whatever's happening is going on a lot faster than it should."

"What does it feel like?" Jason's face swam in and out of focus. He held a hand to her forehead. "You're cool, but damp."

"Great. It's like they just got turned loose in a free-for-all banquet. Good God, what's going on?"

Erika fought to keep herself conscious. She felt dizzy, and the edges of her sight seemed to collapse inward, into a brown tunnel. Jason's voice became a buzz, growing louder, as if all she could hear was the chittering of millions of nanocannibals voraciously working their way through her body.

Chaotic, psychedelic nightmares faded into bursts of static and twinkling lights. When she opened her eyes, she felt as if she were falling, dissolving. . . . She reached out to steady herself and found that she was sliding from a padded couch. Back at . . . Moonbase Columbus?

Jason Dvorak's face appeared, wearing a ridiculous grin. "It's alive, Igor!"

"What?" Her mouth was dry, cottony, and tasted terrible. "Who's

Igor?"

"It's about time you woke up. You've been out five hours."

Erika tried to struggle up from the couch, but he firmly pushed her back. "What happened to me?"

"Well, it worked—or at least everyone thinks it did. Once I got you on the couch, I managed to get hold of Compton-Reason on Earth and Bernard Chu here. They led me through the procedure for keeping track of your vitals, and it looks like you were completely purged of the nanocannibals within fifteen minutes. I brought you back to Columbus for monitoring."

"What about Jordan? Dr. Parvu? Does he know what I did?"

He shook his head. "He's been offline, but the weatherstats showed a big storm over McMurdo Sound. Don't worry. We'll get back in touch with him." He squeezed her shoulder.

"You haven't heard the best news: remember how the Assemblers must have originally been transmitted to us, by touch? Well, your nanocannibals have done the same thing—Bernard Chu tested my blood, and he can't find any trace," he grimaced at the pun, "I mean any evidence, of Assemblers there either. Transmitted through the skin, the nanocannibals are working their way through everyone who's infected."

Erika interrupted with a feeble wave. "You said I was out for a few hours. Weren't you affected yourself? What happened?"

"I was dizzy and feverish for a few minutes, but it passed. Chu thinks you suffered more from fatigue than from Destroyers."

Erika ran a tongue over her teeth. They felt as if they were covered with fur. "Could I get some water?" After she drank, she said, "You know, I'm not even sure what I did to create those things."

"Taylor's group is working to come up with a few theories. They'll probably milk dozens of journal articles out of it."

Erika sighed. "It still seems too easy."

Jason's expression grew more serious. "It's not over yet. The Agency thinks it was too easy themselves. They're not even going to consider letting us back to Earth for quite a while."

Erika sat up too fast and felt dizzy again. "Why not? If all of us check out clean, what are they worried about?"

"The Daedalus construction," he said. "They still don't know what it is, and they're terrified. It looks almost finished and they're afraid we've all been . . . well, *possessed* by the aliens. They don't know what the nanomachine infestation did to us. And neither do we."

CHAPTER 19

Moonbase Columbus

With Newellen sitting beside him in the surface transport, Bernard Chu watched the autopiloted supply shuttle come in low across the cratered horizon. They both craned their necks to look through the slanted front window of the vehicle.

Like a satellite racing across the black sky, the shuttle first appeared as a gleaming white dot. The dot grew until Chu could discern ragged edges at crazy angles with no aerodynamic constraints, gangly antennas, and landing pods.

The Agency hadn't written them off yet. The sheer presence of the shuttle showed they had some sympathy for the people under lunar quarantine. At least Celeste was still sending them food.

As the shuttle grew closer, Chu could imagine the rumble it would send across the lunar plain if there had been an atmosphere. The shuttle approached the surface quickly, kicking up a cloud of dust that obscured the distant landing area.

"Robotic landing worked like a charm," said Newellen. "Better not rub Zimmerman's nose in it. He hates that autopilot stuff."

"Let's get going." Chu indicated the transport vehicle's controls. It felt good to be outside working again on the Moon. He could hear Newellen's breathing over the suit radio as the other man eased the vehicle forward to meet the shuttle.

His thoughts turned to the supply shuttle and all that it meant. Though the automated piloting systems had always been in place for emergency telepresent landings, all regular shuttles required a human in the loop. Though it would have been vastly cheaper for many missions to send a bare-bones ship without the frills a human pilot required, United Space Agency policy insisted on it. But now Celeste refused to send any more people into the plague site.

But they had all been cured. *Cured, dammit!* They were clean, not a nanomachine showed up on any test. Celeste should let them run back to safety on Earth. What was she waiting for?

It was that nightmarish construction out at Daedalus. Dvorak had been spending more and more time going

over the analyses, trying to second-guess the builders, to no avail. Flybys documented the inexorable progress, but they still knew nothing more about what its purpose was. Celeste wanted to keep them there as guinea pigs, an expendable investigation team. He was tempted to send somebody out to Daedalus to poke around.

Of course, he would have to get Dvorak's approval to try something like that. Or maybe he didn't. Dvorak didn't seem too interested in keeping his command, now that Chu had returned. Dvorak had never struck him as someone who really cared about power or responsibility, but seemed more wrapped up in his own interests.

"Hey, watch out for that depression." He gestured out the window.

Newellen nodded curtly inside his helmet. "I see it, plenty of time. I can ride a bicycle almost as fast as this thing moves."

Now that the landing area dust had settled, drifting to the surface like settling snowflakes, the shuttle stood in the raw sunlight.

Chu wondered what it would take to refurbish it. What would stop them from adding some more fuel, disabling the telepresent autopilot, and having Bryan Zed haul them all back to Earth? Zed's L-1 shuttle used volatile liquid hydrogen, impossible to produce at this point on the Moon. These shuttles used methane, which they had plenty of.

Somebody could calculate an appropriate orbit, even without the *Collins* transfer station. They would survive the trip—they'd need to worry only about being blasted out of the skies by Earth-based defenses. Just how serious was

Celeste after all."

As Newellen brought the flatbed transport up to the shuttle, Chu worried that the craft might have landed poorly on its pods. But it looked stable enough. He checked his chin mike. "Can you get a relay to base?"

Newellen leaned forward and fiddled with the communications port. Ever since the *Collins* had been destroyed, they couldn't bounce their communications off L1 anymore; since the L2 relay was on the wrong side of the Moon, they were limited to line-of-sight transmissions. They had had to place backup K-band relays around the crater walls to communicate even at short distances.

"Link's up."

Chu cleared his throat. "The shuttle made it. Columbus. Our pantries are full again for the time being."

"Make sure the bastards didn't booby trap it when you enter," said Cyndi Saffro's voice. Chu grunted, but didn't reply to her bitter warning.

They climbed down off the flatbed tower and trudged toward the shuttle, keeping away from its still-hot engines. A ladder unfolded as Newellen pressed the actuator. The single door slid open and seemed to beckon them forward. The interior had not been pressurized.

Newellen waved Chu forward. "I don't know we should have brought the air. We didn't know what design they were sending down." He looked at the legs of the ladder. "Boy, I wonder where they got this ancient wreck."

"It's an old Russian job, probably scheduled for dismantling," Chu said.

Not human-rated anymore. Expendable. The word expendable made

them both fall silent for a few seconds, but Chu set foot on the ladder to climb up.

"It's all yours," Newellen said, not mentioning the fact that he might have difficulty squeezing his beefy frame through the shuttle door.

Chu worked his way up the aluminum ladder, disoriented, making sure he positioned his foot firmly on each rung before shifting his weight. The ladder was a relic from old days that didn't make sense—spend a couple of billion dollars getting to the Moon, and then as an afterthought strap on a couple of rungs and vertical bars that cost a few bucks and change.

By the time he reached the top, he was out of breath. He didn't weigh much on the Moon, but compared to the last month he had spent in zero-g aboard the *Collins*, he felt as if he weighed a ton. He didn't know how well he would ever survive back on Earth in full gravity—but it no longer looked like he would have the chance to find out.

"You OK up there?"

"Yeah," returned Chu.

The door to the supply shuttle opened directly into the control room—there was no airlock, just like the old lunar landers. It saved weight and was much easier to engineer. The craft's interior was not pretty, but high in utility. The Russians had done a good job outfitting the emergency craft. Low-current LEDs were set above old-fashioned mechanical switches; the control panel jutted out at an odd angle, put together with welding technology instead of milled composites. Extra controls were jammed next to the main systems, relying on redundancy instead of computerized

heuristic fault-finding for backup.

Chu stepped forward. A sheet of plastic was taped to the control panel, directly in front of the empty pilot's seat. Inside the plastic, on a sheet of paper, he read:

FOOD AND MEDICAL SUPPLIES ARE LOCATED IN THE HOLD. WE INCLUDED A 5 PERCENT SURPLUS OF FUEL FOR LANDING ONLY.—FUEL FOR TAKEOFF IS NOT, REPEAT NOT, AVAILABLE.

ADDITIONALLY, A BIOLOGICAL AGENT WAS RELEASED INTO THE REMAINING FUEL PRECISELY TWO (2) MINUTES AFTER PUMP SHUTDOWN.—THE FUEL LINE AND TANKS SHOULD BE ENTIRELY CORRODED BY THE TIME YOU READ THIS. DON'T WORRY, WE'LL FIND SOME WAY TO BRING YOU HOME. YOUR WELL-BEING IS OUR HIGHEST PRIORITY.

—DIRECTOR CELESTE MCCONNELL

She didn't even sign it herself. A "Sorry, hang in there guys!" was scribbled at the bottom of the note, obviously put on by the crew that had sealed the craft.

Chu reached forward, and after searching for a moment, joggled the pump switch. The LED blinked from amber to green, then burned a bright red. Directly above the PUMP STATUS indicator, another row of LEDs burned red.

"You bitch." Chu slammed his hand down against the control panel. He barely felt it through the thick glove.

The whole thing sucked. Of course McConnell wouldn't risk sending a shuttle that could return to Earth—there was too great a chance that one of the Columbus people would defy her quar-

antine and try to get back. As he himself had been contemplating. And with no fuel for Zed's L-1 shuttle, that left only the low-velocity methane-fueled hoppers—and they barely had enough thrust to reach lunar orbit, and nowhere near the delta-vee required to reach Earth.

That was fine logic if you were back on Earth. But the fact that Celeste obviously didn't trust them—didn't trust her long-time supporter Bernard Chu of all people!—made him seethe inside.

He recalled the precautions taken before the *Apollo 10* shot. Tom Stafford, one of the fly-by-the-seat-of-your-pants astronauts back in the 1960s, had been assigned to pilot a lunar module to within nine kilometers of the Moon's surface. Traveling across space from Earth to the Moon to be brought up short by only nine kilometers sounded a bit too tempting, or that's what the administrators thought. How could they be sure Stafford wouldn't suffer "transmission difficulties" and "accidentally" land the craft after all, becoming the first human to set down on the Moon?

So before lift-off, knowing just how cocky some astronauts were, NASA officials had taken Stafford to the contractors who had built the lunar module. There, Stafford was personally shown how much the module weighed, and how much fuel it carried. They took him step-by-step through all the calculations that proved the module was absolutely, positively a thousand pounds too heavy to leave the lunar surface if he broke orders and landed the craft. No matter how much he might want to land, Stafford would know in his gut that the

“You’d better believe you’d never fly again if you did.”

Chu repeated the same way now. He pondered on the idea of trying to clean out the inner tank, patch it and try to seal it off the Moon, just to spite the agency—but he, too, was no fool.

Chu tore the plastic-covered note from the parcel. The people stranded on the moon had been bitter before. This was the last, another slap in the face.

“Someone on Earth thinks about you now!” He opened the note in his patch before heading for the door to the hold below him.

It was empty and plenteous of food.

The other lunar inhabitants greeted Chu with a transport and supplies with a friendly grin, but they helped bring in the necessary food and medicine, and the necessary bay. Cyndi Salito covered a large pileup of dehydrated food. Chu growled. “What, no dry food here?” What the hell are they doing? How can you live on calcium carbonate?

Salito handed off a bag of supplies to Benjamin Zimmerman, who was standing nearby. A line of crewmen extended along the length of the inner corridor, waiting to shift the extra packages into overhead nets and storage cubicles.

Zimmerman answered her in a deadpan voice. “They want us to keep our heads down. It’s bad for the arteries. But if worse, we might die of a heart attack.”

Salito’s eyes widened at the remark. Benjamin snickered back a laugh. It was the most cautious thing he had ever heard of. Zimmerman said, “If it had in fact been meant as a joke.”

Once the supplies were stowed, Chu walked among the people, offering words of encouragement, feeling like the moonbase commander again. Jason Dvorak couldn’t be bothered to be there, instead spending his time back over at the Sim-Mars lab. What did Erika Trace have left to do over there anyway? Weren’t they all purged of their contamination?

As he patted Salito on the back, she stared grimly at him. Most of the crew spoke in low murmurs to each other, if at all. Depression had descended again—quite a difference from just a few days ago, when Erika Trace had announced her “cure” for the alien infestation. Everyone should be out dancing on the regolith right now, but they—like himself—did not trust the Agency to lift the quarantine anytime soon, and most of them wanted to flee home now.

Chu would have to provide a good example, strong leadership. Perhaps he would even take official command of the moonbase from Dvorak. Somehow, he doubted Dvorak would even mind.

Chu had been forced to follow orders and go up to the *Collins*. Just as Dvorak had been thrust into his place. Now, Dvorak must realize that the only right thing to do was to give up his unwanted command here. Leave it in more experienced hands. It was time to push whatever buttons he could with Celeste McConnell—her friendship seemed to be fading fast.

He squeezed past Newellen, and the others in the tunnel, and made his way to the control center. “Someone bring up Agency Headquarters. I need to speak with Director McConnell.”

The technician—someone Chu did not recognize, probably one of the new people brought in on the last rotation—turned, a question written on his face.

“Well?” Chu asked.

The tech searched for words. “It’s eight o’clock in the evening there—twenty hundred hours.”

“Well, then try her at home. You do have the access code, don’t you? If not, I’ll give it to you myself.”

Five minutes passed before the tech could track her down. Celeste wore a neon sweatsuit, and tendrils of damp hair stuck to her forehead. In the background, her two big dogs barked and played with each other. She gave Chu a bland look that was tight at the lips. She nodded into the stereochip. “Hello, Bernard. Is everything going all right?”

“We just unloaded the supply shuttle, Celeste.”

“We were waiting for your confirmation. Shouldn’t you have called through the official line to local Mission Control? I assume that everything came through in good shape.”

“Except for the fuel tanks.” He made his voice sound bewildered and sarcastic at the same time. “Someone using your name played a terrible joke on us. They wrote us a letter, typed your name on the bottom, saying they sabotaged the fuel tanks so that the shuttle is useless now. Now, I know you wouldn’t have had anything to do with such an action—”

She set her mouth, showing impatience. “You know why we had to do that, Bernard. Same thing as with the *Collins*. We can’t take chances, no matter how many tests show that you are

not infected. Give it a little time for confirmation. Dr. Taylor at MIT has publicly said that there is a small chance that the infestation has only grown dormant, like a retrovirus. No one knows what might stimulate the nanomachines. And only one of them needs to get to Earth, maybe brought down by some hot-dog hero from the moonbase. I don’t want to take that risk.”

“If you can’t trust the people you sent up here, who can you trust, Celeste? You hand-picked each and every one of us.”

She moved her head back and forth. “You know I’m sorry. But until we can find out exactly what is going on, and what that damned thing is on *Daedalus*, we . . .” She stopped herself in mid-sentence and straightened. “I won’t get into that any further. Is there anything else I can help you with?”

“No compromise on the quarantine?”

“None. That is closed for discussion. For now. If the situation changes, we will reconsider.”

“If the situation changes! How can it change? We’re all clean.”

“Bernard. Stop it.”

He stared at her. “Is there anything we can do then?”

She looked momentarily surprised. It was the only chink in her armor he had seen for some time now. “Your orders remain unchanged: take any action you think necessary to ensure the survival of your crew—without jeopardizing Earth, of course.”

Chu studied her for a long time. The light delay added to the effect that she was staying still. More sweat stood out on her forehead than he had seen a mo-

ment ago.

He saw in front of him the woman that had saved his life onboard the *Grissom*. Whatever her sixth sense was, he owed his life to it. He should know better than to argue with it.

"OK then—give me command back of Moonbase Columbus."

She pursed her lips. "Bernard—"

"You heard me, Celeste. I'm practically in charge now. Just make it official."

She waited several beats, finally lowering her eyes. "All right. I was considering that anyway. I'll inform Dvorak."

Chu nodded. Celeste had pulled him out of this job just to let him be a station keeper, but that had had its place too. *Who else could have discovered Erika Trace's nanotech infestation, if he himself had not been doing biomedical studies on the Collins?* He had brought the microgravity research up there, started taking baseline data. If he had not caught Erika's infection right there, the alien plague would be spreading like fire through all of humanity, making AIDS look like a minor cold in comparison.

With all that Celeste had done, with all of her proven insight, he knew he shouldn't be so angry at her. She just might be the one person responsible for ensuring the survival of mankind.

But as Chu switched off, he still cursed her for abandoning them.

CHAPTER 20

Moonbase Columbus

Take any action necessary to ensure the survival of your crew.

McConnell's words rang in Bernard Chu's ears. He hadn't spent all that time in astronaut training and periodic re-

fresher courses learning how to roll over and die. He knew how to find options, to determine what he could do and how he could fight back. Now it was for real.

The ordeal on the *Grissom* seven years ago had taught him that he might not always get a second chance. Celeste wasn't giving him any second chances. She had dumped it all back in his lap. OK then, she had no right to complain if she didn't agree with his tactics from now on. He was going to make her pay attention. He had to convince Celeste to let them all come home.

Rubbing his jaw, Chu wandered into the commissary, which was kept open to accommodate the different working hours of the crew. Since days and nights on the Moon were two weeks long, Earthbound work schedules meant little.

Tables and chairs fashioned of scrap metal from the original cargo landers made up the decor. Only a third of the fifty-meter-long cylinder was used for eating; the galley and food storage areas were hidden behind a sectional curtain of plastic blankets. Some crew members had scrawled sarcastic but generally good-natured graffiti over the walls; others had pinned pictures of home to the plastic blanket.

Lon Newellen and Bryan Zimmerman were the only two people in the commissary. When Chu entered, Newellen held up what appeared to be a slice of pizza. "Come on in, Dr. Chu. Care for a piece?"

Chu glanced at the food in disbelief. "Is that what it looks like?" Their diets had always been rigidly controlled by the agency. "Whatever happened to all that high-protein, low-fat stuff the dieti-

cians require you to eat?"

"Here." Newellen pushed a plate holding the last slice of pizza. "Take a bite."

Chu pulled a chair across from the two men, trying to decide if he wanted to be sociable or be annoyed. His eyes lit up as he tasted the slice. "This is good. Very good. What in the world did you do?"

Newellen slapped Zimmerman on the back. The pilot grinned weakly, then returned to his flat expression. "Zimmerbuddy, here, is our secret weapon." Newellen's bulging frame and Zimmerman's straight-backed posture made them look like Laurel and Hardy. "Oregano, basil, bay leaf. You know—spices. Just like Marco effing Polo! Zimmerbuddy brought it with him. All that stuff the Agency said would be bad for our metabolism."

"Personal items," Bryan Zimmerman said. "I am allowed five kilograms on each flight."

"Ever since they decided we were going to be part of the life-sciences database, Zimmerbuddy has been stashing this stuff away and bringing it with him," Newellen said. "You'd be amazed at the trades you can make with the Japanese."

Chu ran his tongue around the inside of his mouth, tasting the pizza again. First the years on Columbus, then months up on the *Collins*—it had been a long time since he had tasted food that wasn't overly bland and healthful.

Chu said, "This has been going on underneath my nose the whole time?" He should have known that some type of smuggling would occur, but cold-fish Bryan Zed as the perpetrator? The

thought of these supposed straight arrows circumventing the Agency's storm trooper dietary plans nearly made Chu laugh. The overriding purpose of the long-range life sciences experiments was to control the entire colony's diet, to ensure with a strict accounting of intake and caloric expenditure that real differences in the human metabolism might finally be understood. Not only would the results have benefited the upcoming Mars mission, but it would have helped the medical community as a whole. Now all the data had to be questioned.

Zimmerman shrugged. "Life's got to go on."

Newellen scrunched up his face. "Now that the Agency has put us on permanent hold, why should we keep suffering for their stupid nutritional experiments? Maybe one reason we were infected by those nanocritters was because of our bland diet. A little bit of cayenne pepper might be the perfect antidote."

Bryan Zed smiled innocently. "Personally, I like the idea of thumbing my nose at the Agency for stranding us here."

Chu narrowed his eyes. That insipid letter Celeste had placed in the robot supply shuttle had made him feel betrayed, written off by the one person he always thought he could count on. Chu couldn't depend on her to come to the rescue any more; he had to try something of his own before they all died, before that alien construction was completed and triggered itself.

And Chu decided he wouldn't mind throwing a wrench in Celeste's works right now, either.

He suddenly stood, knocking his chair backward to the module floor. Newellen and Zimmerman blinked at him in astonishment. Chu gathered his thoughts before he turned to them. "What can we salvage from the dead supply shuttle to get to Farside? Can we patch the fuel tanks long enough to get it that far?"

Newellen looked puzzled. "The shuttle's engines are fueled with a LOX-hydrogen mixture, same as Zed's. The hoppers used on the moonbase are methane based. We can crack methane on the surface, but there's no way we can make liquid-hydrogen."

Chu shook his head. "That's not what I mean. Perhaps between the two shuttles and a hopper, we can deliver a bomb to Daedalus."

Zimmerman raised his eyebrows, then shrugged his shoulders. "If my shuttle can't go anywhere, then let's cannibalize it so we can do something about that construction before it gets finished."

"He wants to do *what*?"

Jason gently pushed Erika back into her chair by the Sim-Mars testing station. "You've got to understand where he's coming from before raising a stink."

"I understand. He's come back from the *Collins* and has taken over your job—"

"He's much better suited for command than I am." Jason sounded too defensive.

"He's taken over your job and now he feels like he's got to prove something."

Jason ran a hand through his dark

curly hair. He could hear her South Carolina accent much more clearly when she was upset. "Erika, it's a good option. There's no reason not to try it. At least we'll go down swinging."

"But what's it going to accomplish? Even you haven't been able to figure out what the construction is supposed to be." Her eyes narrowed. "You don't believe this dormancy theory that Taylor is pushing, do you? That the nanocannibals are still hiding in our muscle tissue and waiting to surge back once they receive some signal?"

Jason held up his hands. "All I know is that Chu thinks he can use one of the hoppers to drop a bomb on that structure. We might be able to wipe them out. Or at least wreck that thing they're building. Have you seen the flyover images? It's not changing much—so the aliens must be nearly finished, and we still don't know what the hell they're building. This just might get rid of them."

"How?" She flipped her blond hair behind one ear. "My God, Jase, there are billions upon billions of nanocritters at Daedalus! What happens if that bomb just scatters them across the surface?"

Jason shook his head. Somehow it didn't bother him when Erika called him "Jase." Not like Margaret at all. "I don't know."

She stood. "Well, we've got to do something then. To protect ourselves in case Chu's plan doesn't work!"

The hopper sat a good five kilometers from the landing pad; if anything went wrong and the hopper or the shuttle hulk blew up, nothing else could be damaged. Only one other hopper remained

at the moonbase.

Bernard Chu watched as the modified refueler filled the shuttle's salvaged hydrogen tank, now mounted inside the hopper. It had been a tight fit, but by removing all of the fixtures intended for human use, Cyndi Salito had managed to force the shuttle's cryogenic H₂ tank inside the hopper. Bryan Zed had watched grim faced—as usual—as they dismantled his shuttle for the scheme.

Salito's voice came over Chu's headset. "We've got a steady flow rate now. I don't want to increase it more than this. I just don't have any experience with this stuff."

"Neither does anybody else," said Chu. *Which is why we're lucky as hell that we're able to tap informational resources back on Earth*, he thought.

He had contacted Celeste, pulled as many strings of guilt as he could manage, and got her to promise him several things. It had taken only a matter of hours to dig up the appropriate explosives experts who could explain how a minor change in the regeneration equipment would produce a supply of nitrogen and oxygen; chemical stores had provided glycerol as well as concentrated nitric and sulfuric acids. As an unappreciated joke, Celeste had even transmitted an online copy of the *Anarchist's Cookbook*.

Cyndi Salito had set to work adding the glycerol to the acids, drawing off the top layer of the mixture and then washing it with water and sodium carbonate. When she had finished, Salito had managed to cook up several drums of old-fashioned nitroglycerin. They added that to containers of all the explosive rocket fuel they could scavenge

from Bryan Zed's shuttle as well as the useless supply ship.

"We're going to blow the hell out of that sucker," Cyndi said over the suit-mike. "I sure hope it's a good idea."

As he watched, Chu wondered to himself why such a relatively simple idea had fallen to him. Why hadn't the people back on Earth thought of delivering an explosive out to Daedalus if they were so frightened of the nanotech construction?

No matter. The important thing was that they had the hopper available now, and with Salito's change to the refueler, the ton and a half of nitro was being pumped into Zimmerman's shuttle's tank along with about five thousand gallons of rocket fuel.

"We've got three-quarters of the tank full now, Dr. Chu." He saw a space-suited figure bounding his way from out of the fringes of his suit faceplate. Cyndi Salito. She said, "No topping off, though. I don't want the whole shebang blowing up in our face."

"And you still think it can take the lift-off OK?"

She probably would have shrugged if the bulky constant-volume spacesuit would have allowed her that much freedom of movement. "I still insist we get the hell out of Dodge when this thing launches. Lift-offs are a bit bumpy, you know—even with quaint little methane engines. This safety distance of five kilometers is for the birds once the hopper gets off the ground—if it explodes then, the blast could send pieces everywhere."

Cyndi looked up from the bank of diagnostics in the control center. Her

station was set away from the main holotank and depended on solid-state read-outs rather than holograms projected into the central tank. The room was darkened, packed with most of the moonbase crew. "Ready when you are, Dr. Chu," she said.

Newellen glanced around the crew. "Hey, has anyone notified Jason at Sim-Mars?"

Chu scowled, not wanting to think about the former commander hiding in the isolation lab, as if there wasn't more important work to be done here.

"We've got him hooked up through the secondary relay," Salito said. "He should be getting the feed along with us."

"Let's do it, then," said Chu. "No use waiting for Earth to OK it. We're the ones on the line here, and this is our show."

Working the virtual joysticks with his massive hands, Newellen paused. "Uh, you don't want a countdown or anything like that, do you?"

Bryan Zimmerman hovered beside him, watching the sequence of events; Cyndi Salito stood close to him, looking as if she were going to explode. "Come on! The longer you let that nitro wait, the more likely something could go wrong!"

"OK. OK. Don't be so touchy."

Chu motioned with his head. "You heard her."

Newellen jabbed at the virtual controls. An instant later, the image of the hopper in the holotank shuddered. Dust flew up, obscuring the lower part of the view. The holotank seemed to vibrate. Suddenly, the hopper shot up and out of view.

"She's off, and no explosion," said Salito. She leaned into the projected diagnostics. Green lights from the controls reflected off her face. "Looks like we've got a good trajectory, and she's holding together. Good job on those patch-up welds."

"Does this mean it'll make it?" asked Newellen.

Salito straightened. "We'll know in half an hour. Max g loading was at takeoff. Since the nitro survived that, there's no reason to worry. None at all."

"I'm going to start worrying as soon as it prangs into the artifact!" Newellen said. "Then we'll see what the aliens decide to do. What if they get pissed?"

"Three . . . two . . . one," Salito said. "And, now!"

The control room became dead quiet. Every diagnostic on Salito's panel showed no activity. Chu wet his lips before speaking. "Did it work?"

"Give us another minute for the S wave to get here, boss," Newellen said. "We'll be able to tell from the seismic shock if it was merely an impact or if the nitro detonated. Thud or thunder."

He twisted his large frame in the chair and read off the seismographs that fluttered beneath their glass-enclosed cage. "I've got two stations reporting now and it looks good, as far as magnitude goes. Big boom. Once the S wave gets here I'll have a fix on the exact location."

Chu merely nodded. It would have been so much easier if the satellite at L-2 had monitoring capability, rather than just the bare instrumentation necessary

for a relay station.

"Got it, got it, got it!" Newellen announced. He stood and scanned the seismograph. "A direct hit, smack in the middle of the artifact! And it made a big kaboom."

Salito folded her arms and looked smug. "That much nitro should have taken out more than the entire structure! There's probably a crater within the crater."

Chu spoke rapidly, snapping his fingers. "Launch the javelin probe. I want a look at it now. As soon as it gets a chance to cool down, we need to validate via IR that we've stopped all nanotech activity."

As he stepped back, Chu watched the team swing into action. Even though no confirmation had yet come through, the morale of the entire base had lifted. At least now they had something to look forward to. They had struck a blow. They had done something instead of sitting around and playing victim.

Chu prayed that he hadn't made things worse. What if the alien nanocritters decided to strike back?

The control room had only a skeleton crew when Newellen approached Bernard Chu with a handful of further results. "Take a look."

Newellen used a chubby finger to set up a playback cube, calling up his own files. As the image appeared, Chu felt a sudden sense of vertigo. "Walk me through this, if you please."

Newellen set the playback to slow motion and pushed a finger into the holotank. "The javelin is coming down off its ballistic trajectory, here, and has rotated so the ground is 'down.'" The

view swung around, moving from a backdrop of stars to the mottled black-on-gray of lunar regolith. Everything looked eerie in the infra-red spectrum; most of the nightside surface was cold, showing no heat being emanated. "Any second now it will pass directly over the artifact."

Chu watched, half expecting to see no change in the mysterious structure, half wanting to see it leveled to the crater floor. As the javelin approached, he sucked in a breath.

Portions of the Daedalus complex were down, disconnected. But the super strong diamond-woven fibers comprising the structure seemed unharmed. The perfectly symmetric hole from which the artifact had sprung now showed irregular features where part of the surface had collapsed, revealing an extensive network of unexpected catacombs beneath the crater floor.

But the main image that stayed with Bernard Chu was that the area glowed a brilliant white in the IR, brighter than it had ever been before—showing that nanotech activity had increased over an order of magnitude since the explosion.

"That's not just residual heat from the blast is it?" Chu asked, already suspecting the answer.

"No way! That stuff permeates everything. They're swarming all over the place like ants after a rainstorm."

Chu watched the transmissions as the javelin went over, then impacted the regolith, cutting off the image. He whispered, "We didn't do a thing, did we? All we did was to make them start over. And spread them out farther."

"Yeah," said Newellen, "we sure stirred them up good." He waited a

beat. "Now they seem to be in even more of a hurry."

CHAPTER 21

Washington, D.C.

Compared to this, a war would have been a piece of cake. Major General Pritchard thought.

Lips drawn tight, Pritchard looked out the office window toward the Air and Space Museum. At times like these, Pritchard envied his military classmates, still on active duty at the Pentagon some three miles away. The Pentagon types only had to worry about smashing the hell out of whomever the president told them to—a fast, clean job. And no president had given such orders for years.

Pritchard, on the other hand, had to deal with a threat that was anything but certain. Nothing about the alien construction was certain. Was it even a threat at all?

An old flat-television played quietly in his office. Pritchard watched the Cable NewsNet from the corner of his eye, though he concentrated mainly on the Smithsonian complex across the street. The National Air and Space Museum contained relics of other times mankind had found ways to solve insurmountable problems. Maybe someday there would also be a model of the Daedalus structure on exhibit. If the human race survived.

For the past year the Air and Space Museum had been negotiating with Pritchard as the Space Agency liaison for new material to display: lunar hoppers taken out of service, prototypes of the stegosauruslike He-3 mining rovers, Jason Dvorak's blueprints for a remod-

eled Columbus. Within six months, a new wing of the museum would open, devoted entirely to the Moon-Mars initiative.

By that time, Pritchard thought, there might not even be a lunar colony in existence! The Farside construction had put everything in question. Could the Agency risk continuing any project without knowing the true nature of the alien race behind the nanomachines?

As Pritchard's gaze lingered on the white marble buildings, he heard a chanting crowd on the television set. He swung around in his chair. The camera panned over thousands of people. Some held up signs, many shook their fists in the air. All of them were chanting something Pritchard could not make out.

"Where is this?" he asked.

The screen displayed a slug line: STANFORD UNIVERSITY.

The voice of the news commentator came up over the noise. "The crowd is estimated to be over thirty thousand by the police, and a hundred thousand by the organizers. People are very concerned about the threat of nanotechnology, whether it be from the Farside of the Moon, or closer to home here in California. Researchers at Stanford have refused to come out and meet with the demonstrators—"

The scene switched to the Daedalus construction—an image two weeks old, Pritchard noticed. The newsnets had played similar stories two or three times an evening for the past month or so. With the destruction of the *Collins*, public interest and panic had soared.

Suddenly, an unknown threat had fallen in everyone's lap. The security

they had felt from years of peace now wavered with paranoia. ALIEN INVASION! screamed the tabloids.

As Pritchard watched the protesting crowd, he knew that this nanotech menace seemed even more threatening than “radioactivity,” which had caused unreasoning panic among the stubborn and uneducated for generations. At least people could explain what radioactivity was, and they could take precautions against it. But the self-replicating nanotech menace was something no one had a handle on.

Some people had cheered yesterday’s attempt by Bernard Chu to blow up the construction, while others had screamed bloody murder about provoking the alien presence, about giving the wrong message to another technological civilization. Pritchard knew it had been a hot-dog act by Chu, more to spite Celeste than to protect the moonbase, and Pritchard didn’t approve of such drastic actions. The setback to the Daedalus construction should have calmed the world somewhat, though. Now they had a little more breathing room.

But the public would not be reassured so easily.

He turned away from the CNN televised images of chanting crowds, and swung his gaze across downtown Washington. It seemed so peaceful out there, humid air, tourists, fountains spraying. Agency Headquarters hadn’t yet been the focus of many protests—but the nanotech labs would only be the first place people would hit.

Anti-war demonstrations took their anger to the defense contractors, the laboratories that produced the weapons, and even the soldiers themselves. But

after a while, they lashed out at the people responsible for making the policy. It was only a matter of time.

If Pritchard could just find a way to make them feel safe again while the Agency worked on the real solution. If he could show the public he was taking decisive action, lull them into a sense of security. . . .

Pritchard leaned forward and slapped at the intercom on his desk. “Jeff?”

His aide’s voice came back within seconds. “Yes, sir?”

“I need some information, as soon as you can trace it for me. The International Verification Initiative watchdog team—what can you get me on it? What devices have they got available, and how can I get my hands on them? What authority do I need?”

After a pause, Jeff responded. “I’ve sent the electronic servant through our combined databases. It should have all the information on your terminal in a few minutes. You have the authority to contact the IVI directly on an Undersecretary level. Even Director McConnell can’t get any higher because of diplomatic protocol. Shall I initiate a contact for you?”

Pritchard thought fast. Dealing with an agency not within the US government made things tricky. The United Space Agency could supposedly get around those barriers, being an “international” agency itself. But because they were housed, staffed, and mostly underwritten by the US, the Agency carried only “lip-service” diplomatic credentials. The Verification Initiative, on the other hand, was a true international commission. But the IVI was the key to what he had in mind.

Pritchard said, "I need to speak with Director McConnell first. Is she in?"

Two heartbeats passed. "She's over at the Hill. Do you want me to raise her?"

Pritchard thought briefly. He was a big boy, and things were changing too damned fast to worry about covering his butt every time. No one had thought up anything better yet, so he decided to go ahead with his decision. He drew in a breath.

"No, but I need to put in a call for a press conference. Wait, make that a video statement instead. We'll issue it to the newsnets and do a conference to answer their questions another time." He glanced at the Stanford mob scene on the television, then at his watch.

"Make sure the studio room is open. I want to go on in an hour."

Very well, General. Ready in forty-five minutes."

As his aide clicked off, Pritchard thought, *I sure hope I know what the hell I'm doing*.

The technician pointed at Pritchard and mouthed, "Three, two, one—you're on." A red light came on over the triad cameras mounted at 120 degree intervals from him around the studio. Simon Pritchard tried not to look at the cameras, but instead stared into the stereochip that showed his features on the wallscreen. Minutes earlier he had finished combing his hair, and had checked to make sure his military jacket was immaculate. He didn't have as many medals, pins, or insignia as his contemporaries, but that was the price he paid for being a scholar in a warrior's world.

Assemblers of Infinity

Pritchard said, "Good afternoon. As I have said before, the United Space Agency will keep you updated during this time of crisis. After yesterday's attempt to use explosives against the alien construction on the Moon, we now know that conventional methods of eradicating the nanotechnological phenomenon will not work. Though we believe the explosion has set back the work of the machines for a time, they seem to be recovering rapidly. We still don't know what it is they are building, nor do we seem able to stop it—even if we wanted to.

"The United Space Agency believes it is imperative to keep this alien technology at bay until we know its purpose, until we can be sure it is not a threat. We need some ace in the hole, a defense we can count on if—and I repeat, *if*—the Daedalus construction turns out to be something we should fear."

He concentrated on maintaining a grave expression. "Exactly one half hour ago, the United Space Agency formally petitioned the International Verification Initiative, the sole international organization tasked with the accounting of nuclear weapons. Since they are headquartered in Washington, D.C., we expect a response from them shortly. A go-ahead from the IVI would allow the United Space Agency to remove up to six nuclear devices from this nation's last nuclear stockpile."

He paused long enough for that to sink in. He wondered, when this was broadcast, how many home viewers would stand up and cheer, and how many would scream in outrage?

"We plan to transport these devices

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onboard a robotically controlled ship, in the safest manner possible, to Daedalus crater on the lunar Farside. Once the shipment has been delivered, it is our plan to have Columbus personnel install these six devices in a ring around the crater—as a safety measure only. We must make the alien presence know we are serious. We must be prepared, just in case the construction turns out to be a weapon of some kind directed against Earth.

“We will install a total chemical equivalent of over twenty million tons of TNT, with each device capable of producing a crater over a mile in diameter. In event of an emergency, we will detonate the devices to ensure that the alien artifact is completely destroyed.”

For a moment he let himself feel immensely relieved he had not allowed any of the newsnet reps into the studio room. He couldn’t handle the questions right now. Pritchard nodded at the camera, and said, “We will keep you updated. Thank you.”

He continued to stare toward the stereo chip until a red light above the unit blinked out. Pritchard relaxed his shoulders for the first time in what seemed like hours. The technicians scrambled around to straighten up the room. Someone else was already passing the tape through the classification people, but Pritchard could veto anything they complained about. He was more worried about what Celeste would say. But somehow, he knew she would approve.

The Agency would soon be inundated with protest from all sides. It was bad enough to have the anti-nanotech freaks upset at him. Now he’d be bringing the old anti-nuke protestors out of the

woodwork, too.

It would have been a lot easier to fight a war, he thought again.

CHAPTER 22

Sim-Mars

For the second time in his life, Jason Dvorak knew what it was like to be run over by a truck.

The first time had been when Margaret demanded a divorce. The second time was the helpless feeling after having this unwanted command snatched away from him. Jason could feel it eating at him, making him want to do something instead of letting the bureaucracy and the circumstances jerk him around.

Jason hadn’t particularly resented it when McConnell placed Bernard Chu back in command—the other man was much better suited to the task, by any measure. But watching Chu’s idiotic bombing of the Daedalus construction made Jason want to bang his head against the curved wall of the Sim-Mars lab. What were the explosions meant to accomplish?

Chu was a biochemist, not an architect. He had not bothered to figure out how best to damage the Daedalus artifact with conventional explosives. Good God, their instruments showed the thing was made with diamond fiber and diamond foam—it wasn’t a house of straw that could be blown down with a huff and a puff.

True, the nitroglycerine and rocket fuel explosion had knocked out much of the support structure under the regolith, fractured and collapsed some hefty catacombs—Java tubes, maybe?—which had made the alien structure unstable.

No one had even known the tunnels existed before this. Was there more nanotech excavation? How much of the alien complex was actually hidden from view underground? Chu's explosion had also spewed the Daedalus nanocritters far and wide.

Watching the IR flyover afterward, Jason found it painfully clear that the pace of the nanocritters' activity had tripled to repair the damage done. The scattered hot zone had shrunk visibly in an hour, showing that the nanocritters were regrouping at the construction site.

Jason felt safe out at the Sim-Mars lab module with Erika, but he didn't trust his temper around the new commander right now. He turned his back on the main holotank. Erika was on the stool next to him, looking exhausted. Jason said, "OK. I give up. What do we do next?"

What? Erika raised her eyes. She looked wrong-out, as if it didn't matter to her anymore.

Jason dropped his hands to his side. "I mean, what else can they expect us to do?"

Erika's sandy hair clung to the perspiration along her forehead. "Now that somebody's decided the safest course of action is to knock out the construction, Chu was just trying to get rid of it—"

Nobody decided that! Chu just wanted to show off. He could have done the whole damn site alone! Just look at what the explosion did!" He glanced at the infrared view of Daedalus on the holotank behind him. Though the alien structure was in ruin, hot spots of activity showed clearly, reconstructing the damaged framework of the rubble.

"What if we've pissed off the construction boss in charge of your nanocritters? What will they do now? What if they come back here to take apart every scrap of metal on Columbus?"

She shook her head. "These are machines working in some kind of programmed way on a preset blueprint. *Programmed*, Jase. These things don't hold grudges, they don't have a penchant for getting even. What just happened to them could have been a random meteor strike, for all they know. They're machines, not Saberhagen's Berserkers."

"Bronco busters?"

"Berserkers . . . never mind." She stood and walked to the holotank, tapping her finger on its base. "They've just looped back to another part of their construction program, assembling whatever they were supposed to except at an accelerated pace to make up for lost time. Before long, you won't be able to find a scratch from our home-made bomb." Erika sighed. "I don't know what to do now."

"So let's put our heads together." Jason forced a smile for her. "New challenges and all that. You've already found a way to cure us. Come to think of it, would it be too difficult to send some of your nanocannibals over there to stop the construction process?"

Erika's greenish eyes grew wide. "Jase—my God, we've had the answer all along! Why didn't we think of this before?"

"I thought it only worked in our bodies."

"If it works on us, why wouldn't it work on Farside? It'll be like a vaccine for the whole construction site!"

Erika was already speaking to the holotank controller. "Computer, bring up Bernard Chu at Moonbase Columbus immediately! Priority one, or whatever the urgent category is."

"Priority A," Jason said.

"Priority A!"

Jason moved closer to Erika. In front of him, she had turned to the experimentation chamber, preparing the enclosed crucible to accept more nanocritter samples. She grabbed Jason by the ears and pulled his face to hers for a quick peck on the lips.

"I have to make a new batch of Destroyers," she said. "Once we've stopped the near-term threat of that construction—if it is a threat—we'll have more than enough time to find out what makes those nanocritters tick."

Chu appeared in the holotank, bleary-eyed in front of the transceiver. Grinning, Erika knew she was going to give him something that would really wake him up.

The first IR overflight showed images exactly as Erika had expected.

Five hours earlier, Moonbase Columbus had launched another projectile at the alien construction site, filled with an electrostatically insulated sample of Erika's modified Destroyers. Comparing it to a vaccine against an infection on the Moon's surface, she had convinced Chu that the Destroyers would self-replicate and defeat the rest of the alien nanomachines. Within twenty-four hours the nanotech activity should have decreased by about 95 percent, with only a few nanocannibals left to clean up the rest.

Standing again in the control center

of Moonbase Columbus, Erika felt immense relief as the infrared map from the first flyover javelin displayed pockets of intense activity—but the overall concentration of alien nanomachines had decreased dramatically. A few people in the control center applauded. Agency Select broadcast it all live. Celeste McConnell sent her personal congratulations.

All indications were that Erika's Destroyers were slaughtering the critters swarming around the gossamer construction. The nanocannibals wouldn't tear down the structure itself, merely "disinfect" it. It would be like an entomologist cleaning out a wasp nest before studying its structure. Somebody—maybe even Erika herself—could safely go to the site to get an up-close view of what the extraterrestrial blueprint carried. Who could tell what might be buried under those new catacombs Chu's bomb had cracked open?

Upon seeing the decreased IR activity, Chu immediately broadcast a new videoloop to Earth.

With her legs trembling even in the low lunar gravity, Erika went back to the moonbase room she shared with Cyndi Salito. Up and down the module quarters, other exiles from the *Collins* crowded in with moonbase personnel. With Erika gone to Sim-Mars most of the time, and with Salito working odd hours, they had crossed paths only a few times. This time, the dim underground room was empty. With a sigh, Erika lay back on the flex-polymer bunk and closed her eyes to take a nap. Next javelin in five hours. By that time the nanocannibals should be halfway through mopping up. . . .

Erika hurried into the control center, nearly late for the arrival of the second probe. She had fallen asleep to uneasy dreams and had awakened with only time enough to wipe a cold towel across her face. Jason had met her in the halls, coming to fetch her before she was late.

When they entered the bustling room, Newellen brought up several cubes showing perspectives of the incoming javelin. Chu, sitting in the prime focus of the holocameras, was already broad-casting live. From the side, Cyndi called up an image of the previous extent of the nanocritters' IR hot zone, then the much-dimmer mapping of the infestation five hours earlier. The hot spots still showed areas of intense nanomachine activity.

"We expect to see a similar reduction in population," Chu was saying to his unseen audience. "We'll confirm this in just a moment."

The IR image speckled and resolved into grainy colors. Using the morphologies Erika had determined from her first work, Newellen had developed image-enhancement techniques that could determine the gross characteristics of large congregations of a particular type of nanocritter. "Packs," he called them. Yellow indicated the standard Assemblers, clustered over the structure of the construction itself; green showed the packs of Disassemblers, combing the regolith for raw materials they would ship molecule by molecule to the waiting Assemblers. Unseen, but scattered throughout the population were the much larger Controllers, information substations that directed the operations, as well as the Courier Programmers that

carried messages and instructions through the entire population.

Erika's nanocannibals were coded red. The processed image from the first flyover showed bright red sweeping over the site like a tidal wave, consuming all the nanomachines it encountered. She expected the color coding of the rest of the area to be overwhelmingly red after ten hours.

The javelin soared over the lunar surface as Daedalus crater came into view. "Here we are," Chu said. "Images coming in now. We are processing them real-time."

The view in the holotank rotated and grew to take up the entire volume. It took on the garish colors of the data-massaged infrared signal. But the colors did not look right. Not at all.

"Oh no," Erika said, at a loss for any other words.

The image glowed in sharp relief. A mosaic of colors glittered in the tank. Black areas covered the regolith, the construction, the entire crater floor, swallowing up most of the red—the red that signified the nanoDestroyers. Bright blots of yellow and green—Assemblers and Disassemblers—had resurged, filling areas that the red had dominated only five hours before.

Jason moved next to Salito. "Is the contrast adjusted properly?"

"That's a real image we're getting back," she said, looking bewildered.

The diamond thread spires holding up the alien structure burned bright in the infrared from nanomachines swarming over the columns. Everywhere the alien complex stood out in vivid detail: the parabolic curves of the "petal" segments, humplike structures that lay off

to the side, bright cracks showing where immense tunnels branched away from the central pit.

Chu seemed to have forgotten he was transmitting. "What are all the black areas?"

Newellen said, "We color-encoded with black to signify an unknown morphology of nanocritter. We're seeing something new. Completely new."

Erika whispered, "This can't be true."

She sensed Jason moving close to her. The control center became too quiet. "What do you mean?" he asked. "What is all this about?"

"An unknown species of nanocritter." She looked at Jason, her eyes wide. Her words were probably being picked up by Agency Select and broadcast everywhere. "They can't replicate that fast. Those are my nanocannibals, I think. They've been reprogrammed. Or the other nanocritters have been. Daedalus set up a classic immune-system response—they sent out a new form of machines like white corpuscles."

She stared at the image of the Daedalus construction. "This is much more aggressive, and I don't think they'll tolerate any more attacks from us. They're learning to protect themselves." ■

CONCLUDED IN NEXT ISSUE. . . .

● Sometimes I regret that I cannot make up my mind to work more at home and extempore. The imagination is certainly a faculty which we must develop, one which alone can lead us to the creation of a more exalting and consoling nature than the single brief glance at reality—which in our sight is ever changing, passing like a flash of lightning—can let us perceive.

Vincent Van Gogh

KEVIN J. ANDERSON

Most science fiction writers spend years before making a sale. Most never do get anything published. Kevin J. Anderson got his first sale to *Analog* for 15 years after his preceding "Editorial Assistant" remembers reading



him. He was 17 when Kevin was in high school.

Anderson's first *Analog* appearance was in 1978, and he has since sold thirteen stories for over a hundred short stories and a novel. His first cover story was "The Last Days of the First Cover." Resonance was a finalist for the 1981 Nebula Award, and a finalist for the 1982 Hugo Award. Two collaborations with John D. Long, Boason, and others, "The Last Days of the First Cover," "The Last Days of the First Cover," and "The Last Days of the First Cover." Part of the story was in the Lawrence Sanders Award for Best Laboratory Use of Science Fiction, and was also a finalist for the 1981 Nebula Award.

Each time he has a sale of his best

time pulp writers was to write in any genre: science fiction, fantasy, horror, and you-name-it. Kevin feels that when something is a good story, it's good stuff, no matter what its genre. Only, as a writer he reads more critically than most critics. He warns would-be writers that as you read analytically, to see what your "competition" is doing and to learn from them, you lose your ability to sit back and simply read for pleasure.

Raised in a Wisconsin small town, he earned a bachelor's degree in astrophysics, with a minor in Russian history. His first job has lasted eight years and proved to be an SF writer's dream assignment. There are enormous lasers, computer centers, and research on magnetic fusion, biomedicine, and nuclear weapons spread over a square mile with 9 000 people. His three-days-a-week has included travel to Los Alamos, Washington, Rocky Flats, and the Nevada test site.

Free-lance writing means becoming a temporary near-expert on assorted subjects right quick. For some days at a time, he filled his mind with such items as the details of Custer's last stand, filmmaking in early Hollywood, Bela Lugosi's life in

(continued on page 169)

the reference library

By Tom Easton

Cold as Ice, Charles Sheffield, TOR, \$19.95, 308 pp. (ISBN: 0-312-85139-1).

Jumper, Steven Gould, TOR, \$18.95, 345 pp. (ISBN: 0-312-85272-X).

Count Geiger's Blues, Michael Bishop, TOR, \$19.95, 374 pp. (ISBN: 0-312-85199-5).

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Outnumbering the Dead, Frederik Pohl, St. Martin's, \$14.95, 110 pp. (ISBN: 0-312-07755-6).

Fool for an Agent, Richard Curtis, Writer's Notebook Press (Pulphouse, Box 1227, Eugene, OR 97440), \$5.99 pp. (ISBN: 1-56146-428-7).

Tramp Royale, Robert A. Heinlein, Ace, \$18.95, 372 + x pp. (ISBN: 0-441-82184-7).

Books on Disk

Charles Sheffield is one of our premier writers of hard science fiction, meaning the sort of SF that has to appeal to all readers of that magazine known as "the one with rivets." Occasionally he spreads his wings so wide he might be compared to cosmic dreamers such as Stapledon. More often, he fits comfortably on the shelf with Clarke and Asimov and Heinlein. That is, he writes classic stuff, solid and entertaining and blessed with a sense of very real possibility.

His latest novel, **Cold as Ice**, feels more possible than some. It opens just as the war between the Belt and the Inner Worlds has ended. Four billion are dead. Earth's northern hemisphere is uninhabitable. The Belt is humbled. And some of the war's artificially intelligent weapons are still out there, seeking targets, unrecalable. One such is the Seeker following a converted

freighter carrying refugees from a destroyed asteroid base. Escape and survival are equally impossible. But the nine smallest children, mere babes, can be fitted into nine survival pods and launched to take their chances. Unfortunately, says Sheffield, the post-war chaos is so great that no one hears the pods' automated distress cries, and the batteries run down. Years pass.

A generation later, Camille Hamilton and David Lanmerman are putting the finishing touches on the Distributed Observing System (DOS), a multi-telescope array that can see not only the planets of distant stars but also their continents—and more. Jon Perry, accompanied by journalist Nell Cotter, is studying life on the Pacific Antarctic Ridge and demonstrating extreme competence under pressure. Without warning their projects are shut down and they and themselves among Jupiter's moons, then to confirm the discovery of life in the ocean beneath Europa's ice, Camille to use her mathematical talents for Cyrus Mobarak, the Sun-King, the man who made fusion practical and wishes to warm Europa's waters for human use. David to assist the same man—who is actually his father—in other ways. Nell follows Jon, convinced that news follows him too, and is horribly miffed when he meets Wilsa Sheer, musician and composer extraordinaire, and the two are instant soul-mates. There is conflict on a more political level as well, for Mobarak is opposed by those who wish Europa left intact, pristine, unviolated, its putative life undisturbed, and by those who wish the resources that might make Europa useful used instead to take humanity to the stars.

Meanwhile, in a deep subsurface den on Ganymede, the immensely fat bureaucratic Rustom Battacharya (Bat) is overseeing a recalcitrant linear program-

ming problem for the transport department that employs him. That done, he promptly turns his enormous intellect on something of more interest, relies of the war, particularly a bit of flotsam that speaks of a certain refugee ship and a ruined asteroid and a Seeker, of a Belt weapon used against the Belt's own. A mystery, he thinks, and he begins to dig, even as the author drops a hint or two about the routineness of genetic engineering and the Belt's efforts to develop biological weapons.

Is that enough? Do you need to see Camille and Jon and Wilsa survive experiences that would surely kill anyone else to realize who they are and whence they came? Then you will, even as you follow Sheffield's deft weaving of opposing political forces, human tensions, and titanic wills toward an ending that does a very good job of pulling all the pieces together, even as it leaves room for a sequel or two.

The only thing that's missing is a sidetrip to show just how badly the war trashed Earth's northern half, but that hardly matters to the story. Sheffield has done such a marvelous job that we have to say he has surpassed himself. That is, this one may be his best to date. Don't be surprised to see it on the award ballots.

Steven Gould is an *Analog* writer who has finally committed his first novel. Not surprisingly, that novel, **Jumper**, is fairly *Analogical*—methodical and rational—in tone. It is also traditional enough in content for Gould to say he hopes its basic gimmick—teleportation—is more a “classic trope” than a cliché.

The tale begins when adolescent Davy Rice is offered one beating too many by his alcoholic, abusive father. Quite reflexively and much to his as-

tonishment, he finds himself in the town library. He soon realizes what he can do and how valuable his new talent is for getting out of trouble such as that offered by a chicken-hawk trucker. Is this how his mother disappeared years before, teleporting herself away from her husband's fists? Are there others like him? Or is he alone?

He wastes little time with such thoughts. He loots his father's cash cache and runs away to New York City, where he finds that he is too young to be employable. In desperation, he empties a bank vault one night, gaining enough of a fortune to take care of all his needs for the foreseeable future. He discovers the satisfactions of revenge. He meets a college girl, Millie, on vacation and discovers that distance is no obstacle to romance, as long as he can maintain an illusion of conventional travel.

And then? So far, *Jumper* sounds like pretty conventional wish-fulfillment fantasy. But there is more to it. Davy learns that his mother is alive. They meet. And soon thereafter she is killed by terrorists. He goes hunting for the terrorist ringleader and attracts the attention of the National Security Agency, which wants desperately to get its hands on him, dissect him, learn from him, and/or recruit this perfect secret agent. The NSA kidnaps Millie. Davy kidnaps the NSA chief.

And stalemate. Impasse. Davy will get nowhere until he learns something about the limits of revenge, the immorality of imposing one's will unilaterally upon others, the virtue of impelling rather than compelling.

By the novel's end, of course, Davy has done precisely that. There is hope for his father. The terrorist kingpin is in custody (albeit not until after Gould has played a bit with the righteous thrill of

dropping the man a thousand feet or so before jerking him back to safety). Millie is in his arms again. And he has promised to assist the NSA at least occasionally.

The wish-fulfillment component remains strong. Indeed, it is so strong that I suspect Gould of planning something in the spirit of the *Wild Cards* series. Novel after novel starring Davy Rice as superhero secret agent, or perhaps novel after novel starring assorted wild-talent superheroes. Maybe there'll even be a comic book.

It has been a while since Michael Bishop's last book, so I was happy to see his latest, **Count Geiger's Blues**, in my mailbox. I was less happy when I finished it, though I remained intrigued by how very differently Bishop handles the idea of comic-book superheroes.

The protagonist is Xavier Thaxton, the arts critic of a snooty Suthren newspaper in the fictional metropolis of Salonika in the equally fictional state of Oconee. Snooty champion of all things highbrow and rabid despoiler of all things lowbrow, he believes in and espouses the Nietzschean *Übermensch* or superman. And then, one day, after covering a rural Shaw festival, he skinny-dips in a wooded dell where, unbeknownst to him or the forces of law, order, and environmental protection, a fly-by-night nuclear waste disposal firm has dumped a cargo.

Soon after that, his sister dumps her teen-aged son, the Mick, on him. Mick is a retropunk with an attitude and a fondness for loud, heavy rock and superhero comics, especially the brand produced right there in Salonika. Soon after that, Xavier finds that all things highbrow are giving him the pip—as well as hives, sneezes, fevers, and exu-

dations of pus—and the only thing that can save him is anything lowbrow—a minute or two of rock, a soap opera, a comic. The pip gets worse and worse, until the Mick and Xavier's fashion designer girl friend, Bari, stuff him into a comic book superhero costume and turn him into a walking avatar of just what he despises most. It doesn't help that the hero whose suit he wears, Count Geiger, is a creation of the local comics outfit, even if the suit does cure him, apparently by putting a heavy dose of lowbrow next to his skin.

Perhaps unfortunately, the Mick is working on his critical sensibility too. There's good rock and bad rock, he says. Good comics and bad comics. How dare you condemn what you know nothing of? Here, try this. And this.

And suddenly it's only *some* rock and *some* comics that cure Xavier's pip. The rest make him just as ill as Bach.

Bishop is making a worthwhile point. He is doing so in a witty, satiric way. The momentum he establishes carries the reader easily to the moment when the creator of the Salonikan comics, enraged by Xavier's pungent review, shoots the critic. By now, of course, the reader is half prepared to accept that Xavier's exposure to radiation has turned him into a genuine superhero immune to such petty annoyances. Not surprisingly, once Xavier accepts his transformation, he begins to battle the forces of crime, violence, and bad taste.

This is where Bishop falters. The satire he has painstakingly created now teeters on the brink of farce. He quite properly makes the decision to yank it back from that brink, but then he loses the satire. He becomes heavy-handed and obvious (as soon as the fly-by-night waste disposal service reappears and gets its hands on the antique radiation therapy machine, any reader who re-

members news and *National Geographic* articles knows a good part of what is about to happen). Wit gives way to bathos. The story feels unpolished, unrefined, as if Bishop, now that he has made his point, is rushing to get out of it as gracefully as possible.

Is it just that Bishop is trying to bring both Xavier and the reader back to reality? Down from the triumphant high of fantasy to the blue depression of the mundane? Maybe so, considering the novel's title, but . . .

I praised Peter R. Emshwiller's first novel, *The Host*, in part for its theatricality. The sequel, *Short Blade*, has many good points but is less satisfying because Emshwiller's vision of a Manhattan divided by a sixth-floor deck into an upper realm of racially pure aristocrats (of all races; it's the purity that matters) and a lower realm of oppressed mongrels (plurites) who never see the sun is no longer new to us. Nor does he add enough that is new to make up the deficit. On the other hand, he ends with a transformation of the late Watly Caiper that hints strongly at another sequel, making this the traditionally weak middle volume of a trilogy.

Did I just give it away when I said "the late Watly Caiper"? You know I wouldn't do that to you. If you read the earlier book, you know that Watly died then. Villainess Sentiva Alvedine had used the "hosting" procedure that permits rich Second-Levelers to take holidays in the bodies of desperate First-Levelers to kill her "poovus" (husband) in a way that would get Watly blamed. Watly, blessed with heroic determination, ingenuity, and luck, managed to capture Sentiva, set her up to have his mind hosted by her brain, and then die while in residence. He, a man, ended *The Host* as a woman. And a

pregnant one at that.

Short Blade opens a decade later. Watly's daughter Noonie is a nine-year-old near-psychotic. Watly him/herself is under attack by a psychotic Sentiva, who wants her body back and seems on the verge of getting it. Watly's lover and physician, Alysess, is going a bit mad herself under the strain of a life that shuttles back and forth between First and Second Levels. The First-Level Revolution is about to blow. The cop who killed Watly is now chief of the Second-Level police and reopening his investigation—he thinks maybe Watly is still alive. And Watly is spang in the middle of it all.

The title refers to the implement Sentiva repeatedly demands. She wants to cut the bits of circuitry that contain Watly out of her head. It also refers to Noonie, who has a vicious streak that will be given ample play before the end, after Alysess has left Watly, after Revy has erupted through the deck to slaughter the effete Second-Levelers, after the defense forces have begun their irresistible slaughter of the rebels, after both Watly and Alysess have heroically fought their ways across the embattled metropolis toward the defense command center, after Watly has crawled up the barrel of a nerve cannon to be rescued from the breach (in the breach of time) by the cop who loves her, after, after, after . . .

Sounds good, doesn't it? Witty and satirical and active. Even if it is weaker than *The Host*. Makes you wonder what he'll do next.

In **Alien Earth**, Megan Lindholm supposes that our world's environmental crises will become so bad that the survival of life on Earth will seem unlikely. Thus when the alien Arthroplana and their great living Beastships arrive

to offer aid, the humans accept. They go forth, a few, and accept a zero-environmental-impact lifestyle enforced by a rigid Conservancy. Only unfertile fruit may be eaten. Each harvest must be replaced by a precisely equivalent ration of nutrients. Technology—even computers and information archives and spaceships—must be biodegradable. Humans gain vastly prolonged childhoods, delayed puberties, and extended lives, but they pay with vastly reduced fertility.

Not all are content. The group Earth Affirmed believes that humanity's proper place is on Earth and that Earth must have recovered by now, millennia after the exodus. The Conservancy has already demonstrated its willingness to crush dissidents, but Earth Affirmed intends to gain a peek at Earth, to see for itself whether the birth planet is the toxic ruin the Conservancy insists it is. Accordingly, it recruits John, Captain of the Beastship Evangeline (and yes, the echo of Acadian history seems deliberate) to fly the mission. He will carry instruments that will observe the planet and report directly to the Conservancy on his return, but he will also do a bit of personal observation and collect samples that will let Earth Affirmed correct any government lies. He will also look for the time capsule Earth Affirmed believes was left to aid a human return to Earth.

Lies are a large part of Lindholm's theme. Lies told when the system declares a child evil and corrupt for picking a flower, a man worthless for having cancer, a Beastship a beast when it has been raped from its own starspanning culture and enslaved, the only worthwhile balance of nature a balance of stasis, even though such a balance is far more unstable than the dynamic balance more typical of ecology (think of a uni-

cycle—the only way to stay up is to keep moving). If the system's errors are so obvious that the system itself becomes a strawman and the tale is thereby weakened, well, Lindholm does weave an interesting tale around Captain John, Crew Connie, Arthroplana Tug (who lives inside the Beastship remarkably like a tapeworm), the old-time emigrant Raef whom Tug has saved from cancer with long, long Wait-sleep, and Evangeline herself, who has come to listen in on Raef's dreams and thus to develop an independent mind.

Lindholm's strength is not the creation of suspense (the outcome is never in doubt). Nor does it lie in subtle concealment of her message (the strawman problem is quite real). But she has broad vision, a decent touch with her characters, and the ability to stay atop her unicycle until the curtain falls.

Fred Saberhagen has written some excellent stories—the Berserker series, *An Old Friend of the Family*, *The Mask of the Sun*, and much more—but I haven't paid him nearly enough attention lately, have I? Most recently, he has been producing the long Swords series, and perhaps that's the problem. I haven't read those books because they looked like a too-familiar sort of fantasy. At the same time, I've told myself I really should see what the guy's up to now.

Fortunately, his latest is not Swords fantasy. It's vampire fantasy—but even though that too is a pretty familiar category, I remember *Friend of the Family* fondly. So.

A Question of Time brings back the heroic vampire of Saberhagen's Dracula series. This time the setting is the Grand Canyon. Back in 1935, CCC worker Jake Rezner wanders away from camp and meets a young lady, Camilla, who

takes him home, introduces him to the sculptor Edgar Tyrrell, and tells him he cannot leave. When he tries, he finds that all paths from Tyrrell's Deep Canyon lead to a younger landscape occupied by prehistoric creatures. Tyrrell commands time itself, even as he displays a familiar avoidance of the sun and flexibility of form.

In 1991, Tyrrell's aged widow hires private detectives to hunt for a missing adopted grand-daughter. She gets Joe Keogh and John Southerland, and with them a "Mr. Strangeways" who senses the involvement of the undead and flits to England (where Tyrrell was born in the 1800s) to do a spot of research.

Back in 1935, Jake learns more of what is going on: Tyrrell is sculpting stones mined from the most ancient of strata. He can visit any year he wishes to obtain supplies or servants (though perhaps cattle would be a better word); Camilla met him in the 1960s. The house in which Camilla lives (Tyrrell prefers a cave) has a child's nursery. Jake and Camilla grow desperate to escape and vow to kill their master, or to try.

In 1991, Saberhagen reveals that the widow left Tyrrell in 1933 and later had him declared dead. There was at least one child. And when Mr. Strangeways (Dracula himself, of course) returns from England, he gives us hints of what Tyrrell is up to as both artist and would-be scientist, both a little mad.

The driving force behind this one may be the sense of time one gains from staring at something like the Grand Canyon, where the pages of Earth's history lie open, riffled, revealed, oozing eons as a steak does blood. The artist—either author or sculptor—asks, might that time be grasped and shaped, bent to the will? Might it obey, or might it, like the time most of us know better, prove

slippery, elusive, uncontrollable? The answer is this story.

What about that missing granddaughter? Ah, now, that would be telling. But surely you've read enough novels to predict a happy ending.

Frederik Pohl's novella, **Outnumbering the Dead**, posits a future when children are gestated in animal wombs and at a certain point are given a treatment that makes most of them immortal. Most of them. It just doesn't take on a few, such as the song-and-dance performer Rafael, who is now in his nineties. Those around him—on Earth and throughout the Solar System, ten trillion vastly outnumbering all those humans who have died since the species first appeared—are fascinated, enthralled. Death, except by accident, is an oddity. It is the stuff of quaintness and comedy. Rafael's prognosis, as much as his artistic skill, has made him a superstar.

Rafael emerges from his latest rejuvenating treatment with a bit of dizziness and an extra clumsiness in his step. His dramaturge—meaning here producer, not playwright (which is the only definition the *Oxford English Dictionary* allows)—has a grand production all set to roll, an "Oedipus" based on Sophocles' original. Though it is strangely warped to fit the temper of the times, it does still end with blinding and exile. And it effectively parallels Rafael's decline, retirement, and finally the return of a lost love from a space habitat about to embark on an endless voyage into the interstellar wilderness.

The only significant flaw here lies in the vanishing of a subplot wherein Rafael is offered a rather different path toward the embarking habitat. I can see why it is there, to represent the foreclosing of options that accompanies age and

decline, but I thought it unnecessary in a tale of this length. Without it, Pohl's thought is quite clear and poignant enough.

Richard Curtis is one of the major literary agents on the New York scene. Before he became an agent, he was a professional writer who won awards for humor. His column of commentary on writing and publishing has appeared in *Locus* for years. Occasionally those columns lapse from serious discussion to satire, mockery, even japery, poking pointed fun at jealous authors, editors who never have the time to edit, publishers that seem to publish books only to destroy them, and so on. Once a year, he supplies *Publisher's Weekly* with a long poem laughing at the industry's games of musical chairs, merger mania, and celebrity chasing through the last year.

If you wish to see what all the fuss is about, get Curtis's **Fool for an Agent**. If you have any connection with or interest in the publishing industry, you'll enjoy it.

Tramp Royale is the book Robert A. Heinlein wrote about his and his wife's journey around the world in 1953 and 1954. He couldn't sell it then because of "a slump in the publishing business," says Virginia Heinlein. She could now because RAH had become a literary icon (at least for SF readers). Though he is gone, his name still sells.

Do you want it? Of course you do if you're an insatiable Heinlein fan. Here the Grand Old Man of SF is at his cutest, quipping his way from Colorado to South America to South Africa and Singapore and Australia and onward. He shows us a world dominated by the US, unswamped by hordes of tourists and terrorists, not yet suffering from the environmental (including population) cri-

ses so familiar to us today.

Perhaps that last is the most telling point. E. G. Nisbet, in *Leaving Eden: To Protect and Manage the Earth* (New York: Cambridge University Press, 1991), says that the early 1950s are the last time when our world can be considered remotely in its "natural" condition. Heinlein has thus given us, quite accidentally, a glimpse of a genuine and irretrievable "good old days." He could also see, even then, that "the prime problem facing the human race" which "probably has no solution" is "too many people."

One of the things that made Heinlein so great as a writer was that he looked at the world with open eyes.

BOOKS ON DISK

It looks from here like disktop pub-

lishing might just be on the verge of an explosion. Last month I mentioned Ron Albright's Disktop Publishing Association (1160 Huffman Road, Birmingham, AL 35215; RALBRIGHT on GEnie). Since then, Ted Husted sent me a copy of the DPA's own MS-DOS hypertext reader, complete with Albright's essay on disktopping. Ted also sent a "Floppyback" sampler from FPI Inc., P.O. Box 2084, Hoboken, NJ 07030 (201-319-5312). This is another hypertext reader for MS-DOS machines, and it seems to work quite well (better than the DPA's, and maybe even better than Ted's DART). The sampler includes bits of Twain, Shakespeare, Conan Doyle, and other classic writers to show off its paces and tempt you to buy the full-length floppybacks. Call or write, and say I sent you if you like. ■

(continued from page 161)

the Hungarian resistance after WWI and who was doing what with whom and where was in the Manhattan Project. More recently, he had to research the oil and petroleum-derived problems. It's like cramming for a college exam. After, you can forget most of it.

He goes on another 4-week sampling jaunt in Death Valley. There, he is a hardy writer with his laptop, computer and some books. Hiking and magnificent landscapes recharge his mental batteries, and driven his imagination. Better yet is having a collaborator to bounce

ideas back and forth. Doug Beason turns out to write at about the same speed, has similar strengths in certain areas, and yet provides complementary skills. After preparing a plot outline and biographies for the characters, writing chores are divided up.

Robert Heinlein's mutant character Joe-Jim in *Universe* held strategy conferences between his two heads on one pair of shoulders. Kevin Anderson and Doug Beason manage this feat across 2,500 miles by phone between Livermore and Washington. Several more novels are already projected, including a sequel to *Assemblers of Infinity*. ■

brass tacks

Dear Dr. Schmidt:

I am writing in regard to the editorial "The Right to Hide Arms," (Feb. 1992). There are three significant issues that must be stated in order to really grasp why health institutions function as they do in relationship to HIV testing and universal precautions:

1. There is an element of time called a "window" when someone who is infected with the HIV virus can in fact transmit it but will not test positive.
2. Hepatitis is the greatest killer and crippler of health care workers (about 200 deaths per year). There are thousands of carriers of this virus, mostly unrecognized and of far greater danger in terms of infectivity.
3. There are many instances, such as serious trauma coming into an emergency room or a cardiac arrest in a hallway, in which neither the HIV nor hepatitis status of an individual is known nor can be known prior to treatment being initiated.

Those above conditions make it mandatory that universal precautions be followed. One never knows who is infected with what, so it is necessary to always be cautious. To say that one is only cautious when one positively knows that somebody is infected leads to a false sense of security and potential injury.

It would be counterproductive to have "AIDS" identified on some charts and not others since one is never sure who is infected. However, should a patient be tested for HIV or hepatitis while in a hospital, the results, like other tests, are reported in the chart.

In most reputable institutions if a health care worker is stuck by a contaminated needle, he can immediately start treatment and can find out the HIV status of the patient. Many states mandate that a consent from the patient to do that exam is not even necessary.

There are changes that all institutions should adopt to protect health care workers. These include:

1. Ready accessibility and mandated use of safety equipment in order to easily maintain body substance precautions.
2. Free hepatitis vaccine for all workers exposed to blood and any others who desire it.
3. Mandated education on the transmission and prevention of contagious diseases.
4. Mandated immediate and free testing, follow-up, and treatment of work related injuries.

Your concern for health care workers is admirable. Your plan for rectifying the situation is, however, misguided.

KATHLEEN J. LAWSON

VICE PRESIDENT, NURSING SERVICE
Flint, MI

I would not have written the editorial if my information indicated that all or even most hospitals actually follow the practices you attribute to "most reputable institutions." I was prompted to do so by independent reports from people I know who work in several such institutions that they often don't follow those practices. And if an institution fails to meet your standards of "reputable," that hardly justifies failing to give high-

risk employees every possible protection.

Neither said nor implied that universal precautions should not be followed, or that anyone should only be cautious when one positively knows that somebody is infected. It would not be "counterproductive" to label known high risks. Everybody who works in a hospital knows that the lack of such a sign doesn't guarantee safety, but appreciates the common courtesy of being told when extra danger is known to exist. Inexact but apt analogy: when I walk around my neighborhood, I must always be prepared for run-ins with dogs. I still appreciate signs which warn me of places where such run-ins are particularly likely.

Dear Stanley:

I'd like to address a somewhat sensitive issue concerning racial imagery. As an example, I will use Alexis Glynn Patnet's story "Landfall" in the March 1992 *Analog*. I use this as an example only, and in no way imply any denigration of the author. This issue occurs throughout all media, but I think more often in SF because of mixed racial crews (which indicates improved racial relations in the future).

There are three character descriptions in the story:

1. "a rather . . . tall blonde woman"
 2. "Wing . . . man . . . youngish Asian Asian eyebrows . . . Chinese"
 3. "Atlanta . . . tall black man"
- For unbiased consistency:
1. "tall Caucasian blonde woman"
 2. "yellow . . . man . . . youngish Asian . . . Asian eyebrows . . . Chinese" (no change)
 3. "tall African black man"
- Or, if "tall white blonde woman"
1. "yellow . . . man . . . youngish Asian . . . Asian eyebrows . . . Chi-

nese"

3. "tall black man" (no change)

Most often, characters are assumed to be Caucasian unless given specific racial identifiers. However, the only race we identify by skin color is African (and the white/black, good/evil cultural connotation). We would not add "yellow" to a description of an Asian and rarely add white to the description of a Caucasian, "blonde" being sufficient.

It's a linguistic leftover from an earlier time in human history. Writers, editors and readers need no more than to be aware of the problem, and our language will evolve to reflect an unbiased future.

PHIL REYNOLDS

Rockaway, NJ

I'm all in favor of reducing bias, in language and elsewhere, but it seems to me that your suggestions go farther than necessary, seemingly looking for bias even where none exists and introducing redundancies or inaccuracies. For instance, "Caucasian" is implicit in "blonde" (unless somebody's been into the dye bottle), and a black man is not necessarily African (although his ancestors probably were).

Dear Stan:

Mark Heber's letter (March 1992) states, "The spinoff argument [for space development] is another mirage. . . . I have never seen any article or book that proves that spinoffs even pay back the majority of development costs much less all of it."

Confirmation of our intuitive belief that "space pays" may be found in the 1989 report by the Chapman Research Group in Colorado. A summary of this study, plus another article on NASA spinoffs, may be found in the *Proceedings of National Space Society's 1989 Space Development Conference* (Chicago), published by Univelt, Inc., P.O.

Box 28130, San Diego, CA 92128.

That study examined just 259 *non-space* applications of NASA technology during just the eight-year period 1976-1984. The study found that these 259 applications generated in that short period more than:

- \$21.6 billion in sales and benefits,
- 352,000 (mostly skilled) jobs created or saved, and
- \$355 million in federal corporate income taxes.

Other additional benefits, not quantified in the study, included:

- state corporate income taxes,
- individual personal income taxes paid by those 352,000 workers in largely new industries (e.g., computers, electronics, fabrics, composites, ceramics, metallurgy),
- uncalculable benefits resulting from lives saved and an improved quality of life.

The 259 applications represent only *about 1%* of an estimated 25-30,000 space program spinoffs.

While all government spending results in government purchases, employment and taxes, spending on space goes far beyond that. The benefits cited by the Chapman study were *in addition to* benefits in the space industry itself and *in addition to* the ordinary multiplied effects of any government spending.

If Mr. Heber asks, "Can we afford space?" we now know the answer is yes. If he asks can we afford not to invest in space, the answer is no. We should heed the president of a large Japanese company who was recently quoted: "The space field is the key to winning the high-tech competition with the United States and Europe."

The space program put our most productive people to work. When the money was spent, new industries were left behind to generate more money. If

we shift Space funds to other programs, we might simply be trading one group of unemployed for another—putting to work the current unemployed but simultaneously putting out of work those skilled aerospace workers.

If we waited until all social problems are solved to further space development, we would wait forever.

JEFFREY G. LISS, CHAIRMAN, NSS 1989
SPACE DEVELOPMENT CONFERENCE
Chicago, IL

Dear Dr. Schmidt,

Perhaps Steve Gillett was leaving out details for simplicity, but the article "Chicxulub: the K-T Smoking Gun?" (March 1992) bothered me because the methodology seemed much too sloppy to support the conclusions being drawn. The "argon-argon" dating technique, as he described it, works like this: most argon-40 derives from radioactive decay of potassium-40; some, unfortunately, will derive from atmospheric contamination, but a correction can be made by measuring argon-36, given a knowledge of the proportion of argon-36 to argon-40 in the atmosphere. Instead of measuring the proportion of argon-40 to potassium-40 (which involves errors because different methods must be used to determine the abundances of such chemically different substances), irradiate the sample to transmute a known fraction of the potassium to argon and measure the resulting argon-39, given a knowledge of the ratio of potassium-39 to potassium-40 in "ordinary" potassium.

As the author acknowledges, the argon-40 in the atmosphere, like the argon-40 trapped in the rocks but unlike the argon-36, is also the result of potassium-40 decay. But he fails to note the obvious corollary that the ratio of argon-36 to argon-40 in the atmosphere

cannot have remained constant over the Earth's history, and the time since the K-T boundary is a large enough fraction of that history that the ratio should have changed significantly. Compare the difficulties that radiocarbon daters are now discovering which appear to result from changes in the atmospheric ratio of carbon-14 to carbon-12 over time. Was this taken into account in calculating the atmospheric correction?

More disturbing is the analogous change in the ratio of potassium-39 to potassium-40 in the rock, which goes to the heart of the question: what date is he measuring? Suppose a rock has a potassium-39-to-40 ratio of, say, exactly 20.0, and it sits in the crust for millions of years while some of the potassium-40 decays to argon and the ratio changes to, say, 21.0. Then the rock is melted by some traumatic event, all the argon escapes, the minerals recrystallize into a rock with a starting ratio of 21.0 and argon begins to reaccumulate. Typically, radioactive dating will give us the time the rock was last re-molten, and we could still get this by measuring what the potassium-40 level actually is. But apparently they are measuring the potassium-39 and just assuming that the potassium ratio has the "ordinary" value of, say, 20.5. This does not give us the date the rock melted, nor even the date the potassium ratio was last at its "ordinary" value.

At one point we are told a rock dates to 65.0 million years ago, "right at" the K-T boundary, and later that a rock dates to 65.7 million years ago, "right at" the K-T boundary. Of course, three-digit precision is better than you can hope for, but at the end of the article we are told that three different meteor strikes probably all happened on the same day, from which we can estimate the season and the hour. This is non-

sense. We cannot be sure these rockfalls were not separated by hundreds of thousands of years, even if the dating accuracy is as claimed. If they do not even have two-digit precision, we cannot be sure that we are not talking about meteor strikes millions of years before and after the dinosaur extinction.

ROBERT ECKERT

Pittsburgh, PA

The author replies . . .

Of course I've glossed over many details! As you've pointed out many times, *Analog* is not a technical journal. But these are not problems at all. To take Mr. Eckert's comments in order:

(1) An arithmetic reality check shows that the change in atmospheric Ar-36/Ar-40 ratio is completely negligible for most of Earth history, and indeed unmeasurable for an event as recent as the K-T extinction, because: (a) although the half-life of K-40 is very long, about 1.3 Ga (billion years), it's significantly less than the age of the Earth (4.5 Ga); and (b) the ratio Ar-36/Ar-40 in air is very small (0.337%).

Proofs of these assertions are left as exercises for the reader. For a worst-case scenario, assume that: (a) all atmospheric Ar-40 comes from K-40 decay (i.e., there's no initial Ar-40); (b) all Ar-40 is degassed from the Earth immediately as it's formed; (c) all initial Ar-36 was degassed immediately on the Earth's formation; and (d) no argon is lost from the atmosphere. Remember too that not all K-40 decays to Ar-40; the branching ratio Ar-40/total decay is about 0.110. (The basic law of radioactive decay is $A = A_0 e^{-\lambda t}$ where t is time, A is the amount of the radioactive substance remaining at time t , and A_0 is the initial amount (at time $t = 0$). It's trivial to show that the decay constant λ is related to the half life $t(1/2)$ by: $\lambda = \ln 2 / t(1/2)$. The careful student

will, of course, also make sure that t and λ are expressed in compatible units before beginning calculations!)

The problems of C-14 dating are completely irrelevant: in that system, you're dealing with the decay of an initial value set by (assumed) equilibrium with an (assumed) steady-state concentration of the radionuclide. However, C-14 is a very short-lived cosmogenic nuclide whose abundance depends on the cosmic-ray flux, and thus its "steady state" concentration is sensitive to variations in that flux. K-40, by contrast, is *not* formed continuously; Earth had an initial complement that's been decaying away every since.

(2) Mr. Eckert's second point is incorrect. At any point in Earth's history, *all* potassium *always* has the same ratio of K-40 to K-39, irrespective of the time the K-bearing phase was formed (barring chemical isotope fractionation, which is utterly negligible for potassium). This results because all the K-40 initially in the Earth has been decaying away steadily ever since the Earth's formation, and there are no ongoing sources. (In fact, the ratio of K-40 to total K is also essentially the same at any point, because K-40 is a very small component of terrestrial potassium: currently it's about 1 atom in 10,000, and even 4.5 Ga ago it was only about 1 atom in 1,000. That's why measuring total K only, as in conventional K-Ar dating, would work just fine if you could measure the K precisely enough.)

To be sure, the ratio K-40/K-39 changes over geologic time, so of course K-minerals formed at different times will have had different initial K-40 ratios. But that ratio doesn't stay "frozen in" once the K-mineral is formed; the K-40 continues to decay. So, although (say) a mineral that was formed long ago started with a higher

initial K-40 ratio, the K-40 has decayed away longer; thus its present K-40 ratio is exactly the same as that of a mineral formed more recently in which the K-40 hasn't decayed for as long! So, contrary to Mr. Eckert's assertion, measuring the present K-40 ratio in a mineral would tell us nothing about its age. It is the same in any mineral. (Readers still doubtful can prove this for themselves by using the radioactive decay equation above, and remembering that the Earth begins with only a fixed initial amount A_0 of K-40.)

In fact when we get a mineral's age by K-Ar dating, we are *calculating* the K-40 ratio at its time of formation by measuring the Ar-40 generated since. And that means we need to make sure (a) no argon has been lost; and (b) we count only the argon formed by the K-40 decay in-situ.

Perhaps his misconception stems from confusion with C-14 dating. But to repeat, in K-40 dating we're *not* dealing with the decay of a radionuclide from an initial known concentration.

(3) This comment suggests that Mr. Eckert did not read the article very carefully. The hypothesis of three simultaneous impacts at the K-T boundary is *not* based on exact equality of the age dates—as he correctly points out (and as the article did too, for that matter), the age resolution is much too poor for that—but on the sheer improbability of three large objects *independently* striking the Earth within a narrow slice (< 1 Ma) of geologic time.

In any event, there's enormous literature on isotope geochemistry, of which isotopic dating is a huge subset, and of which Ar-Ar dating is a large (and growing) sub-subset. For an introduction, textbook *Principles of Isotope Geology* by Gunter Faure (2nd ed., Wiley, 1986).

STEVE GILLETT ■

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a calendar of **analog**

upcoming events

29 October-1 November

WORLD FANTASY CONVENTION at Callaway Gardens, Pine Mountain, Ga. Guests: Anne McCaffrey, Michael Bishop, John Farris, Martin H. Greenberg. Limited membership. Registration—\$100 in advance; NO at-door memberships. Info: World Fantasy Convention 92, Box 148, Clarkston GA 30021. (include SASE)

6-8 November

CON*STELLATION XI (northern Alabama SF conference) at Huntsville Hilton, Huntsville Ala. Guests of Honor—Kristine Kathryn Rusch and Dean Wesley Smith; MC—Michael Flynn; Artist Guest of Honor—Stephen Hickman; Fan Guest of Honor—Mike Glicksohn. Registration—\$18 until 30 Sep, \$22 thereafter. Info: Con*Stellation XI, Scorpio, Box 4857, Huntsville AL 35815-4857.

13-15 November

PHILCON (Philadelphia area SF conference) at The Adam's Mark Hotel, Philadelphia, Penna. Principal Speaker—Greg Bear; Guest Artist—Boris Vallejo. Registration—\$20 until 15 September, TBD thereafter. Info: Philcon, Box 8303, Philadelphia PA 19101. (609)764-8294.

13-15 November

SCI-CON 14 (Tidewater area SF conference) at Holiday Inn Executive Center, Virginia Beach, Va. Guest of Honor—Elizabeth Scarborough; Artist Guest of Honor—Don Maitz; Special Guest—Janny Wurts. Registration—\$20 until 1 October, \$25 at the door. Info: Sci-Con 14, Box 9434, Hampton VA 23670.

20-22 November

ORYCON 14 (Oregon SF conference) at the

Red Lion/Columbia River, in Portland, Oregon. GOH: Esther Friesner. Rates: \$20 until 10/31/92; \$25 at the door. (The rates are probable right now.) General interest panels, art show, dealers, readings, filking, masquerade, dances, etc. Info: OryCon 14, PO Box 5703, Portland OR 97228. (503)283-0802.

27-29 November

SILICON (California SF conference) at Santa Clara Westin Hotel, Santa Clara, Calif. Guest of Honor—Robert Jordan; Artist Guest of Honor—Richard Hescox; Fan Guest of Honor—Michelle Sagawa; TM—James P. Blaylock. Info: Silicon '92, Box 8029, San José CA 95155-8612. (408)977-0562.

27-29 November

DARKOVER GRAND COUNCIL MEETING (Annual conference on MZBradley's Darkover books) at Holiday Inn, Timonium, Md. Info: Armida Council, Box 7203, Silver Spring MD 20907. (202)737-4609 (before 11:15 ET).

2-6 September 1993

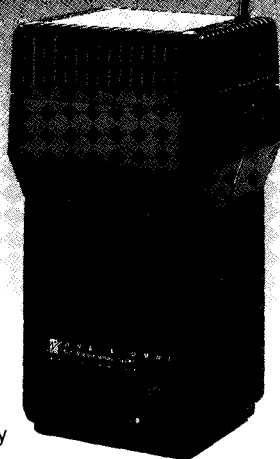
CONFRANCISCO (51st World Science Fiction Convention) at Parc 55, ANA Hotels, Moskone Centre, San Francisco, Calif. Guest of Honor—Larry Niven; Artist Guest of Honor—Alicia Austin; Fan Guests of Honor—Tom Digby and Jan Howard; MC—Guy Gavriel Kay. Registration—\$85 adult/\$30 child until 30 September 1992. Supporting—\$25. This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition—the works. Join now and get to nominate and vote for the Hugo Awards and the John W. Campbell Award for Best New Writer. Info: 712 Bancroft Rd, #1993, Walnut Creek CA 94598. (510)945-1993. CompuServe 72377.3623.

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—Anthony Lewis

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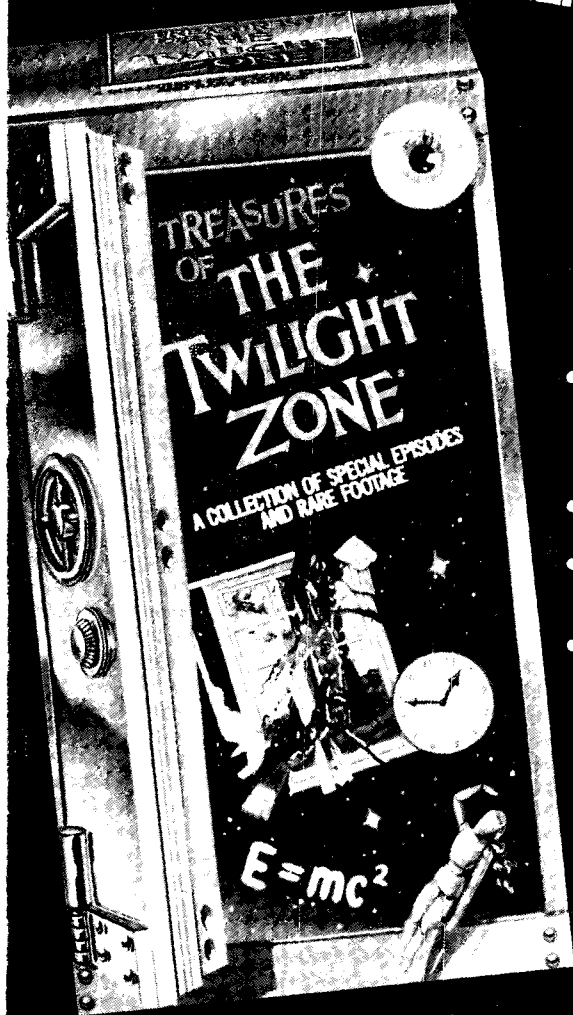
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